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DISEASES OF THE EYE

DISEASES OF THE EYE

A MANUAL FOR STUDENTS AND PRACTITIONERS

BY

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SECOND EDITION

LONDON
J. & A. CHURCHILL
7 GREAT MARLBOROUGH STREET
1912

BRADBURY, AGNEW, & CO. LD., PRINTERS,
LONDON AND TONBRIDGE.

PREFACE TO THE SECOND EDITION

The text has been revised throughout in this edition and several new sections added. Some of the illustrations of the first edition have been transferred to plates, and some new illustrations have been introduced into the text.

My indebtedness for numerous illustrations is in most cases acknowledged in the text. I have to thank Mr. Nettleship and Mr. Holmes Spicer for the use of blocks from Nettleship's "Diseases of the Eye." I am indebted for the original drawings to Mr. Nettleship for Plate III., Fig. 2 ; the figures on Plates IV., V., and VI ; Plate VIII., Fig. 2 ; Plate IX., Fig. 2 ; Plate X., Figs. 1 and 2 ; Plate XI., Fig. 1 ; Plate XII., Fig. 2 ; Plate XIII., Fig. 1 ; and for Figs. 172, 176, 177 ; to Mr. Lister for Plate VIII., Fig. 1 ; Plate XI., Fig. 2 ; Plate XIII., Fig. 2, and for Figs. 191, 194 ; to Mr. Lawford for Plate XIV., Fig. 2, and for Fig. 192 ; and to Mr. Percy Flemming for Plate XIV., Fig. 1.

Those who, having studied this manual, wish to pursue the subject more deeply should read Fuchs's "Textbook of Ophthalmology." They will find Ophthalmic Optics more fully treated in my "Elementary Ophthalmic Optics" (J. & A. Churchill), Pathology in my "Pathology of the Eye" (4 vols., Hodder & Stoughton), Treatment in Hanke's "Treatment of Diseases of the Eye," translated by G. Coats and myself (Hodder & Stoughton).

J. HERBERT PARSONS.

Queen Anne Street, W.,
January, 1912.

the Physiology of Visual Sensations, Colour Vision & Colour Blindness in my "Introduction to the Study of Colour Vision" (Cambridge University Press).

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DISEASES OF THE EYE.

SECTION I.

ANATOMY AND PHYSIOLOGY.

CHAPTER I.

ANATOMY.

The sensory nerves of the body are provided with end organs, by means of which they receive specific physical stimuli and transform them into nerve impulses. The nerves of the special senses are no exceptions to the rule, and the eye is the highly differentiated and complex end organ of the sense of sight.

The wall of the globe is composed of a dense, elastic supporting membrane (Fig. 1). The anterior part of the membrane is transparent—the cornea; the remainder is opaque—the sclerotic. The anterior part of the sclerotic is covered by mucous membrane—the conjunctiva—which is reflected from its surface on to the lids.

The *cornea* consists of three layers: the epithelium, the substantia propria, and Descemet's membrane. The epithelium, which is stratified, may be regarded as the continuation of the conjunctiva over the cornea proper. It lies upon a homogeneous lamina of the substantia propria, called Bowman's membrane. The substantia propia may be regarded as the continuation forwards of the sclerotic. Descemet's membrane is a thin elastic membrane, covered on its posterior surface by endothelium : it may be regarded as the continuation forwards of the uveal tract. We shall see that the relationship of the three layers is of some pathological importance, for when as is often the case the cornea suffers secondarily to some conjunctival complaint the epithelium and superficial layers are most likely to be affected : similarly, in diseases of the sclerotic the substantia propria suffers most, and in diseases of the uveal tract the endothelium, Descemet's membrane,

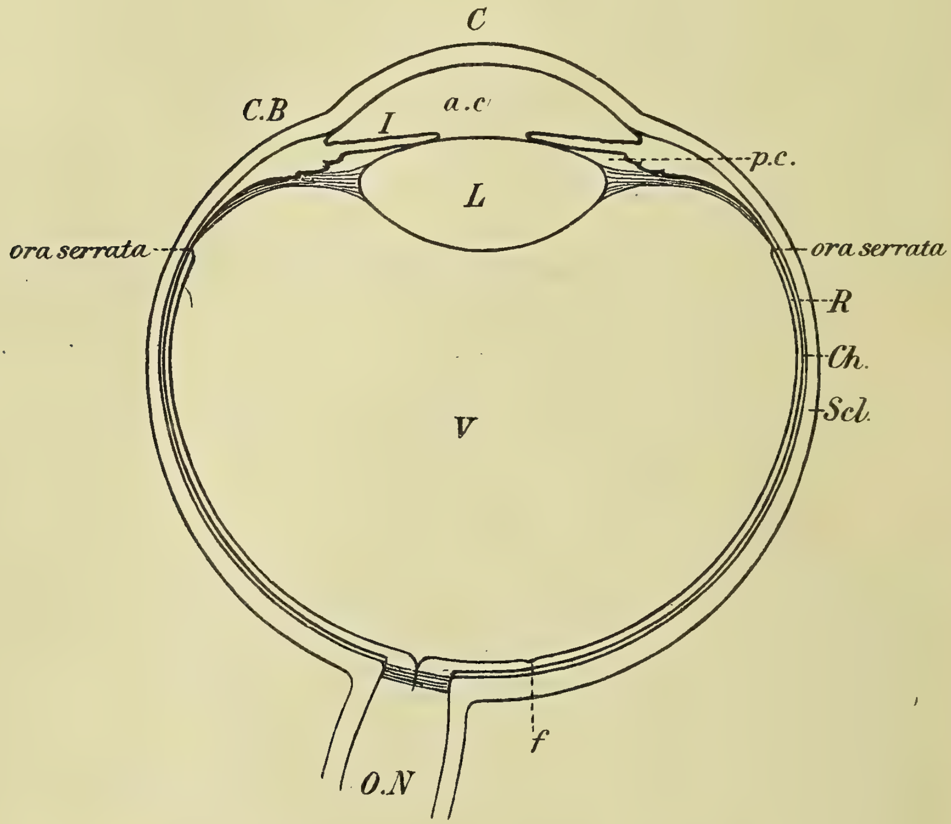

FIG. 1.—Diagrammatic horizontal section of the eye. C, cornea ; *a.c.*, anterior chamber ; I, iris ; C.B., ciliary body ; *p.c.*, posterior chamber ; L, lens ; V, vitreous ; R, retina ; Ch., choroid ; Scl., sclerotic ; *f*, fovea centralis ; O.N., optic nerve.

and the adjoining posterior layers of the substantia propria.

The cornea is set into the sclerotic like a watch glass, *i.e.*, the sclerotic overlaps the cornea all round the periphery. The cornea is very richly supplied with nerve fibres derived from the trigeminal. It has no blood vessels with the exception of minute festoons, about 1 mm. broad, at the periphery; the cornea is therefore dependent for its nourishment upon diffusion of lymph, which is supplied from the conjunctival vessels.

Lining the sclerotic are two membranes: an outer, highly vascular, concerned chiefly in the nutrition of the eye, and comprising the greater part of the uveal tract; and an inner, nervous, the true visual nerve ending, concerned in the reception and transformation of light stimuli, and called the retina.

The uveal tract consists of three parts, of which the two posterior, the choroid and ciliary body, line the sclerotic, whilst the anterior forms a free circular diaphragm, the iris. The plane of the iris is approximately coronal: the aperture of the diaphragm is the pupil. Situated behind the iris and in contact with the pupillary margin is the crystalline lens.

The *anterior chamber* is a space filled with lymph, *the aqueous humour;* it is bounded in front by the cornea, behind by the iris and the part of the anterior surface of the lens which is exposed in the pupil. ~~Since~~ the sclerotic ~~overlaps the cornea at the periphery it~~ enters into the boundaries of the anterior chamber at the part which is known as the angle of the anterior chamber (Fig. 2). In the inner layers of the sclerotic at this part there is a network of venous spaces which is called *the canal of Schlemm.* At the periphery, just anterior to the canal of Schlemm, Descemet's membrane splits up into fibrillæ, which are continuous with a meshwork of fibres stretching between the sclerotic and the iris, and known as the *ligamentum pectinatum iridis.* These fibres are covered by endothelium, which is continuous with that lining the cornea and also with that covering the iris. The spaces in the network of the ligamentum pectinatum iridis are called

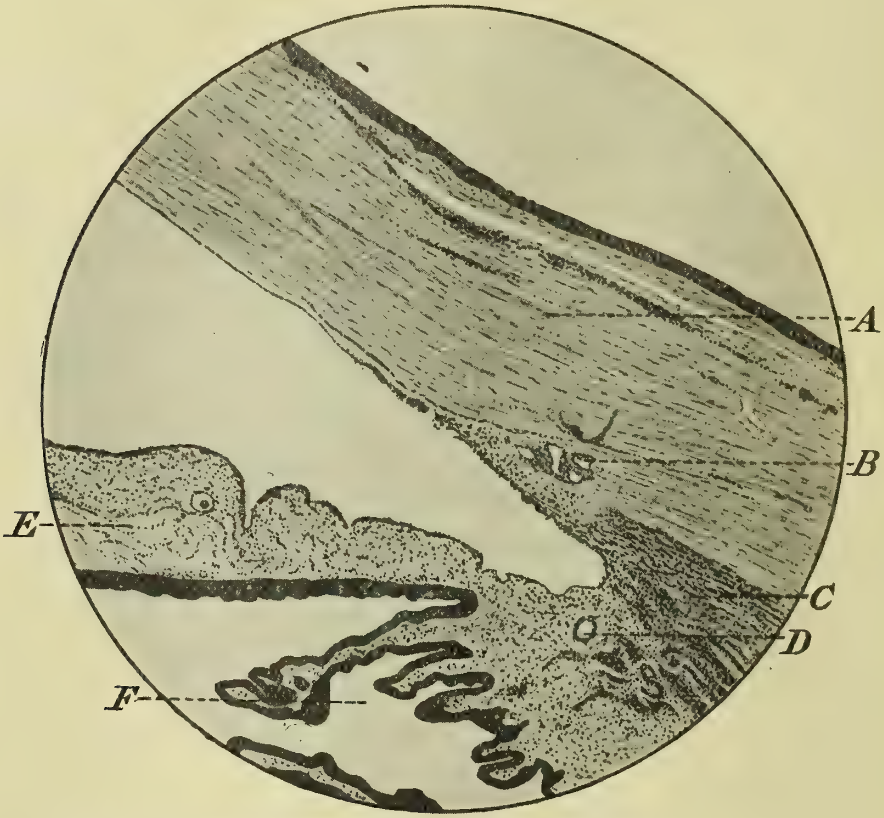

FIG. 2.—Angle of the anterior chamber. A, cornea; B, canal of Schlemm, which appears as several small spaces in the sclerotic just outside the ligamentum pectinatum iridis; it thus consists of irregular anastomosing venous channels which are cut across in the section; C, ciliary muscle; D, circulus arteriosus iridis major; E, iris; F, ciliary processes.

the spaces of Fontana: they are much better developed in lower mammals than in man. The tissue separating the ligamentum pectinatum from the canal of Schlemm is somewhat denser, and there is no free communication between the anterior chamber and the venous plexus, a thin membrane, covered on each surface by endothelium,

being interposed. We shall see that a thorough knowledge of the anatomy of angle of the anterior chamber is essential to the proper understanding of several pathological problems, especially that of glaucoma.

The anterior chamber is about 2·5 mm. deep in the centre in the normal adult: it is shallower in very young children and also in old people.

The uveal tract, as already mentioned, consists of the iris, the ciliary body, and the choroid, from before backwards.

The iris is composed of a pigmented stroma, consisting of branched connective tissue cells and containing a rich supply of blood vessels which run in a radial direction. The stroma is covered on its posterior surface by two layers of pigmented epithelium, which properly belong to the retina and are therefore called the pars iridica retinæ, or pars retinalis iridis. The anterior layer consists of flattened cells, which are very firmly attached to the stroma, the posterior of cubical cells, not so firmly attached to the anterior layer. Near the pupillary margin and concentric with it is a bundle of unstriped muscle fibres, *the sphincter iridis.* There is also a set of cells, elongated in the radial direction, which acts as a *dilatator iridis.*

The anterior surface of the iris is covered with a single layer of endothelium, except at some minute depressions or crypts which are found most at the ciliary border. Here the lymph spaces between the stroma cells communicate directly with the anterior chamber: this is probably a device for ensuring rapid transference of lymph from the iris to the anterior chamber and *vice versâ*, so as to facilitate quick movements of the pupil in response to variations in the intensity of the light falling upon the eye. The iris is thinnest at its attachment to the ciliary body, so that if torn it tends to give way here.

The iris is richly supplied by sensory nerve fibres derived from the trigeminal, a fact which it is important to remember, since touching or cutting the iris, especially if it is inflamed, is intensely painful. The sphincter iridis is supplied by motor nerve fibres derived from the oculomotor nerve, whilst the motor fibres of the dilatator iridis are derived from the cervical sympathetic nerve.

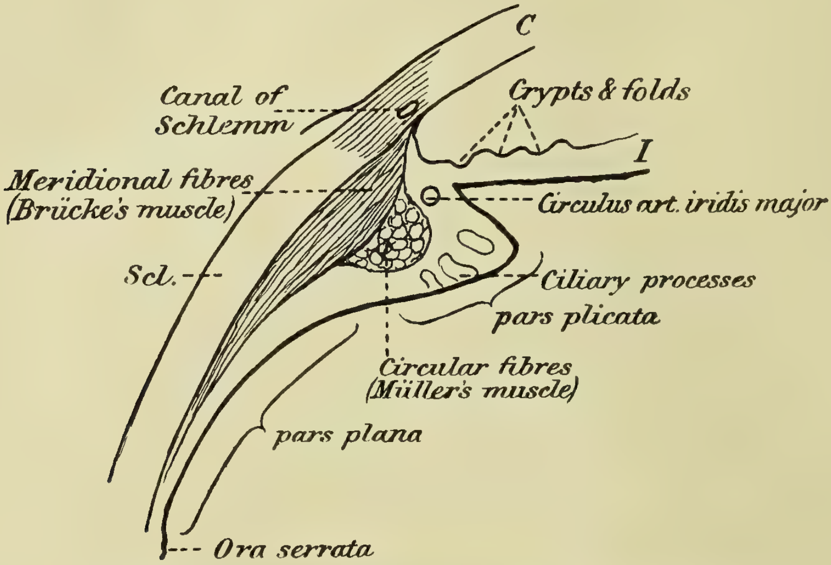
C
Canal of Schlemm
Crypts & folds
I
Meridional fibres (Brücke's muscle)
Circulus art. iridis major
Scl.
Ciliary processes
pars plicata
Circular fibres (Müller's muscle)
pars plana
Ora serrata

FIG. 3.—Diagrammatic meridional section of the ciliary body. Note that the sclerotic overlaps the cornea, as shown by the shading.

The *ciliary body* in antero-posterior section is shaped roughly like an isosceles triangle, with the base forwards. The iris is attached to about the middle of the base, so that a small portion of the ciliary body enters into the posterior boundary of the anterior chamber at the angle (Fig. 3). The chief mass of the ciliary body is composed of unstriped muscle fibres, *the ciliary muscle*. This consists of two parts, an outer, in contact with the sclerotic, consisting of antero-posterior or meridional

fibres, and an inner, consisting of fibres running at right angles to the former, and therefore arranged in a circle concentric with the base of the iris. The meridional fibres can be traced far back, well into the choroid, whereas the circular fibres are confined to the anterior part.

If an eye is cut in half in an antero-posterior direction and the inner surface of the ciliary body is inspected, it will be noticed that the anterior part has a number of folds upon it, whilst the posterior part is smooth. The anterior part is, therefore, called the pars plicata, the posterior, the pars plana. If the plications are counted with the naked eye or under slight magnification, it will be found that there are about seventy in the whole circumference. If microscopical sections are examined, innumerable smaller plications and processes, *the ciliary processes,* will be seen upon the pars plicata. These contain no part of the ciliary muscle, but consist essentially of tufts of blood vessels, not unlike the glomeruli of the kidney. They are covered upon the inner surface by two layers of epithelium, which belong properly to the retina, and are hence called the pars ciliaris retinæ. As in the pars iridica retinæ, the outer layer, corresponding with the anterior in the iris, consists of flattened cells, the inner of cubical cells, but unlike what obtains in the iris, they are not both pigmented, but only the outer layer.

The ciliary body extends backwards as far as the *ora serrata,* at which point the retina proper begins abruptly; the transition from ciliary body to choroid, on the other hand, is gradual, though this line is conveniently accepted as the limit of the two structures. The ora serrata is slightly more anterior on the nasal than on the temporal side.

The ciliary body is richly supplied with sensory nerve fibres derived from the trigeminal, so that great pain results from injury or acute inflammation. The ciliary muscle is supplied with motor fibres from the oculomotor nerve.

The choroid is an extremely vascular membrane in contact everywhere with the sclerotic, though not firmly adherent to it, so that there is a potential space between the two structures, which acts as a lymph space (Fig. 4). On the inner side, the choroid is covered by a thin elastic membrane, the *lamina vitrea*, or *membrane of Bruch.* The blood vessels of the choroid increase in size from within outwards, so that immediately beneath the membrane of Bruch there is a capillary plexus, the *choriocapillaris.* Following upon this is the layer of medium sized vessels, whilst most external are the large vessels. The vessels are held together by a stroma consisting of branched pigmented connective tissue cells. It is easy to remember that the capillaries are innermost, because one of the chief functions of the choroid is to nourish the outer layers of the retina.

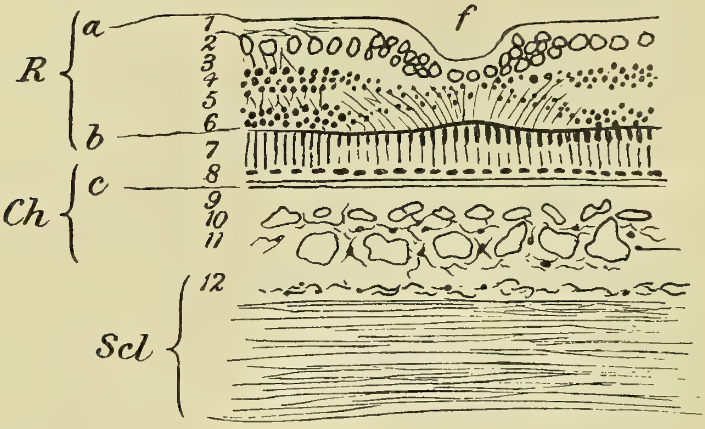

FIG. 4.—Diagrammatic section of retina, choroid, and sclerotic at posterior pole of the eye. R, retina, with *f*, fovea centralis : *a*, internal limiting membrane ; 1, nerve fibre layer ; 2, ganglion cell layer ; 3, internal reticular layer ; 4, internal nuclear layer ; 5, external reticular layer ; 6, external nuclear layer ; *b*, external limiting membrane ; 7, rods and cones ; 8, retinal pigment epithelium. Ch, choroid : *c*, membrana vitrea or membrane of Bruch ; 9, choriocapillaris ; 10, layer of medium-sized vessels or Sattler's layer ; 11, layer of large vessels or Haller's layer. Scl, sclerotic, with 12, lamina fusca on its inner surface.

The choroid is supplied with sensory nerve fibres from the trigeminal.

The *retina* proper corresponds in extent with the choroid, which it lines. As already mentioned, however, and as shown by embryological research, it is continued forwards as a double layer of epithelium as far as the edge of the pupil. If the two layers of epithelium are traced backwards, the anterior layer in the iris is found to be continuous with the outer layer in the ciliary body, and this again is continued into the hexagonal pigment epithelium, which covers the membrane of Bruch. Similarly, the posterior layer in the iris, although pigmented, passes into the inner unpigmented layer of the ciliary body, and this suddenly changes at the ora serrata into the highly complex retina proper.

The retina proper consists of a number of layers. Most external, in contact with the pigment epithelium, is a neural epithelium, the rods and cones (Fig. 4). Following this, in order from without inwards, are the outer nuclear, the outer reticular, the inner nuclear, the inner reticular, the ganglion cell, and the nerve fibre layers. These special nervous constituents are bound together by neuroglia, the better developed vertical strands being called the fibres of Müller. The interlacement of neuroglial fibrils on the outer side form a sort of membrane which acts as a basement membrane for the rods and cones, the outer limiting membrane. Similarly on the inner side the bases of Müller's fibres spread out and form an inner limiting membrane upon the inner surface of the nerve fibre layer. Here the retina is in contact with the vitreous, which also has an extremely delicate bounding membrane, the hyaloid membrane: this is regarded by some as identical with the inner limiting membrane of the retina.

At the optic disc the fibres of the nerve fibre layer pass into the optic nerve, the other layers of the retina stopping short abruptly at the edge of the porus opticus.

At the posterior pole of the eye, which is situated about 3 mm. to the temporal side of the optic disc, a specially differentiated spot is found in the retina of higher mammals (man and monkeys), the *fovea centralis*, or yellow spot. As its name implies, it is a depression or pit, and here only cones are present in the neuro-epithelial layer and the other layers are almost completely absent. The fovea is the most sensitive part of the retina, and it is surrounded by a small area, the macula, which, though not so sensitive, is more so than other parts of the retina. It is here that the nuclear layers become gradually thinned out, whilst on the other hand parts of the reticular layers are specially in evidence: the ganglion cells too, instead of consisting of a single row of cells, are heaped up into several layers. There are no blood vessels in the retina at the macula, so that its nourishment here is entirely dependent upon the choroid (Fig. 5): by way of compensation the meshes of the capillary network of the choriocapillaris are particularly small here.

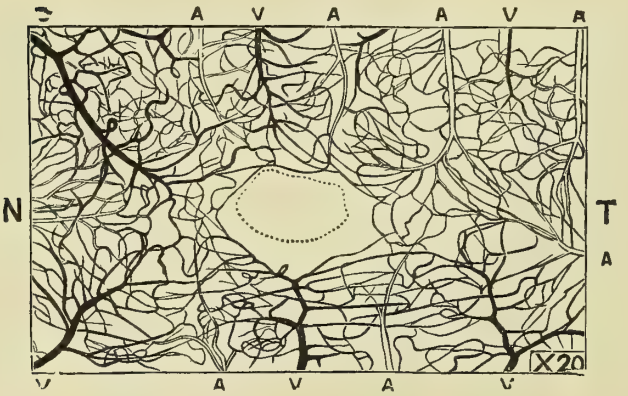

FIG. 5.—Blood vessels in the macular region of the human retina. (Nettleship.) The central gap corresponds with the fovea centralis. N, nasal side ; T, temporal side ; A, arteries ; V, veins. The meshes are much smaller than at the periphery of the retina.

The so-called *optic nerve* is really a lobe of the brain, and therefore belongs properly to the central nervous system. Embryological and morphological investigations show that the bipolar cells of the retina, the nuclei of

which are in the inner nuclear layer, probably correspond with the cells in the dorsal root ganglion of an ordinary sensory nerve (neurons of the first order). Similarly, the ganglion cells correspond morphologically with the cells of the nucleus gracilis, or nucleus cuneatus (neurons of the second order). Hence the part of the visual nervous mechanism which corresponds with an ordinary peripheral sensory nerve is a microscopic cell and its processes situated within the retina itself. All the remainder is really part of the central nervous system, and we shall see that it responds to pathological processes more like the central than the peripheral nervous system.

The porus opticus is the aperture in the sclerotic through which the optic nerve passes. It varies much in shape in different cases, but in all it is traversed by a transverse network of connective tissue fibres containing much elastic tissue, the lamina cribrosa. The fibres of the nerve fibre layer of the retina pass through the meshes of the lamina cribrosa, and on the posterior side they suddenly become surrounded by medullary sheaths. These nerve fibres, which comprise the greater number of the nerve fibres in the so-called optic nerve, are the axis cylinder processes of the ganglion cells of the retina. They are therefore afferent or centripetal fibres, but the optic nerve also contains a few efferent or centrifugal fibres.

The *lens* is a biconvex mass of peculiarly differentiated epithelium. It will be remembered that it is developed from an invagination of the epidermal epiblast of the fœtus, so that what was originally the surface of the epithelium comes to lie in the centre of the lens, the peripheral cells corresponding with the basal cells of the epidermis. Just as the epidermis grows by the proliferation of the basal cells, the old superficial cells being cast off, so the lens grows by the proliferation of the peripheral cells. The old cells, however, cannot be cast off, but become massed together in the centre or nucleus: moreover the newly formed cells elongate into fibres, the lens fibres, which have a rather complicated arrangement. Without going into details, it is important to bear in mind that the nucleus of the lens consists of the oldest cells and the periphery or cortex of the youngest. Further, it must be pointed out that at an early stage the productive basal cells become limited to a single row of cubical cells covering the anterior surface. The mass of epithelium which constitutes the lens is surrounded by a hyaline membrane, the lens capsule, which is thicker over the anterior than over the posterior surface: it is a cuticular deposit secreted by the epithelial cells.

The lens in fœtal life is almost spherical; it gradually becomes flattened so as to assume the biconvex shape. It is held in place by the suspensory ligament or zonule of Zinn. This is not a complete membrane, but consists of bundles of fibrils which pass from the surface of the ciliary body to the capsule. The flattening of the lens is due to these fibrils becoming more and more stretched as the eye grows. The fibrils pass in various directions and the various bundles often cross one another. Thus the most posterior arise from the pars plana of the ciliary body almost as far back as the ora serrata; these lie in contact for a considerable distance with the ciliary body and then curve towards the equator of the lens to be inserted into the capsule; most are inserted slightly anterior to the equator. A second group of bundles spring from the summits and sides of the ciliary processes, i.e., far forwards, and pass backwards to be inserted into the lens capsule, slightly posterior to the equator. A third group pass from the summits of the processes almost directly inwards to be inserted at the equator.

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It will be noticed that there is a somewhat triangular

space between the back of the iris and the anterior surface of the lens, having its apex at the point where the pupillary margin comes in contact with the lens; it is bounded on the outer side by the ciliary body. This is the *posterior chamber*: it contains lymph of the same nature as the aqueous.

Behind the lens is the large vitreous chamber, containing the *vitreous humour*. ~~It~~ is a jelly-like material, intersected by delicate fibrils with a few cells and wandering leucocytes. It is bounded by the excessively delicate hyaloid membrane, but it is doubtful whether this is present at the anterior part where the vitreous is in contact with the lens.

This/

THE BLOOD SUPPLY OF THE EYE.

The arrangement of the blood vessels which supply the eye is peculiar and is of great importance in considering pathological conditions.

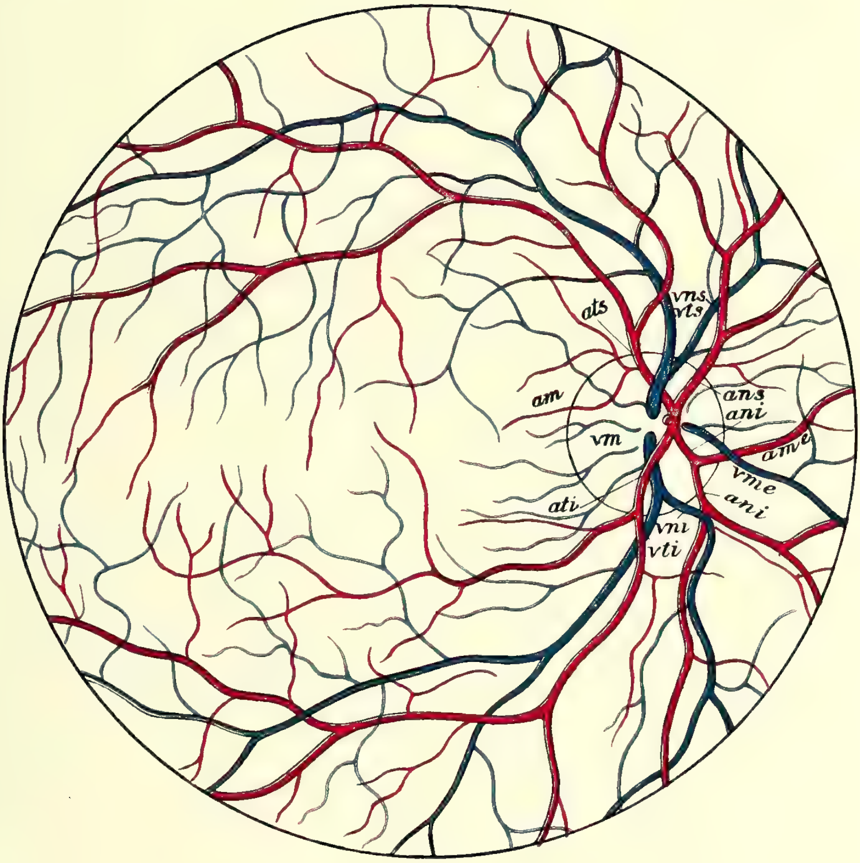
The arteries of the eye in man are all derived from the ophthalmic artery, which is a branch of the internal carotid. The ophthalmic artery has very few and insignificant anastomoses, so that on the arterial side the ocular circulation is an offshoot of the intracranial circulation. This is not the case to so marked a degree of the venous outflow of the eye. Whilst in man most of the blood passes to the cavernous sinus by way of the ophthalmic veins, yet it must be remembered that these anastomose freely in the orbit, the superior ophthalmic vein communicating with the angular vein at the root of the nose, and the inferior ophthalmic vein with the pterygoid plexus. Hence too great stress must not be laid upon the circulation in the retina as a guide to the condition of the intracranial circulation, as has been done in the past.

The retina is supplied by the central artery, which enters the nerve on its lower surface, 15—20 mm. behind the globe. The central artery divides on or slightly below the surface of the disc into the main retinal trunks, which will be considered in detail later (Plate I.). The retinal arteries are end-arteries and have no anastomoses at the ora serrata. The only place where the retinal system anastomoses with any other is in the neighbourhood of the lamina cribrosa. The veins of the retina do not accurately follow the course of the arteries, but they behave similarly at the disc, uniting on or slightly below the surface of the disc to form the central vein of the retina, which accurately follows the course of the corresponding artery.

The uveal tract is supplied by the ciliary arteries, which are divided into three groups—the short posterior, the long posterior, and the anterior (Plate II.; Fig. 6). The short posterior ciliary arteries, about twenty in number, pierce the sclerotic in a ring around the optic nerve, running perpendicularly through the sclera, to which fine branches are given off. The long posterior ciliary arteries, two in number, pierce the sclerotic slightly farther away from the nerve, in the horizontal meridian, one on the nasal, the other on the temporal side. They traverse the sclerotic very obliquely, running in it for a distance of 4 mm. The anterior ciliary arteries are derived from the muscular branches of the ophthalmic artery to the four recti. They pierce the sclerotic ~~near~~ the limbus or corneo-scleral margin, giving off twigs to this region, to the conjunctiva and sclerotic.

The ciliary veins also form three groups—the short posterior ciliary, the venæ vorticosæ, and the anterior ciliary. The short posterior ciliary veins are unimportant; they do not receive any blood from the choroid, but only from the sclerotic. The venæ vorticosæ are the most important, consisting usually of four large trunks which

PLATE I.



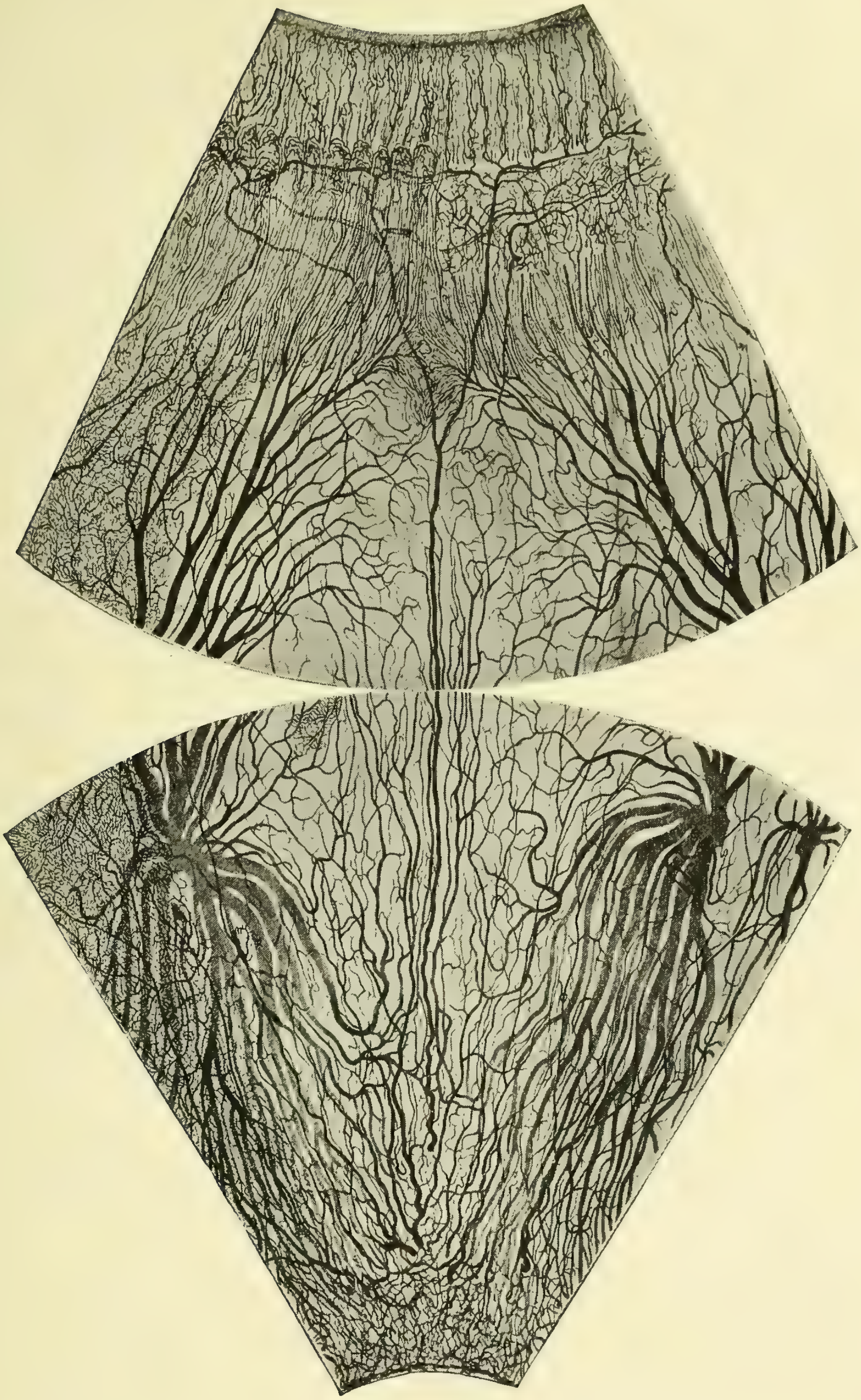


FIG. 6.—Blood vessels of the human uveal tract, injected, from the optic disc to the edge of the iris. (After Leber.) Arteries, black ; veins, paler. Running up the centre is a long posterior ciliary artery. Two vorticose veins and their tributaries are seen. The capillaries are only partially filled in.

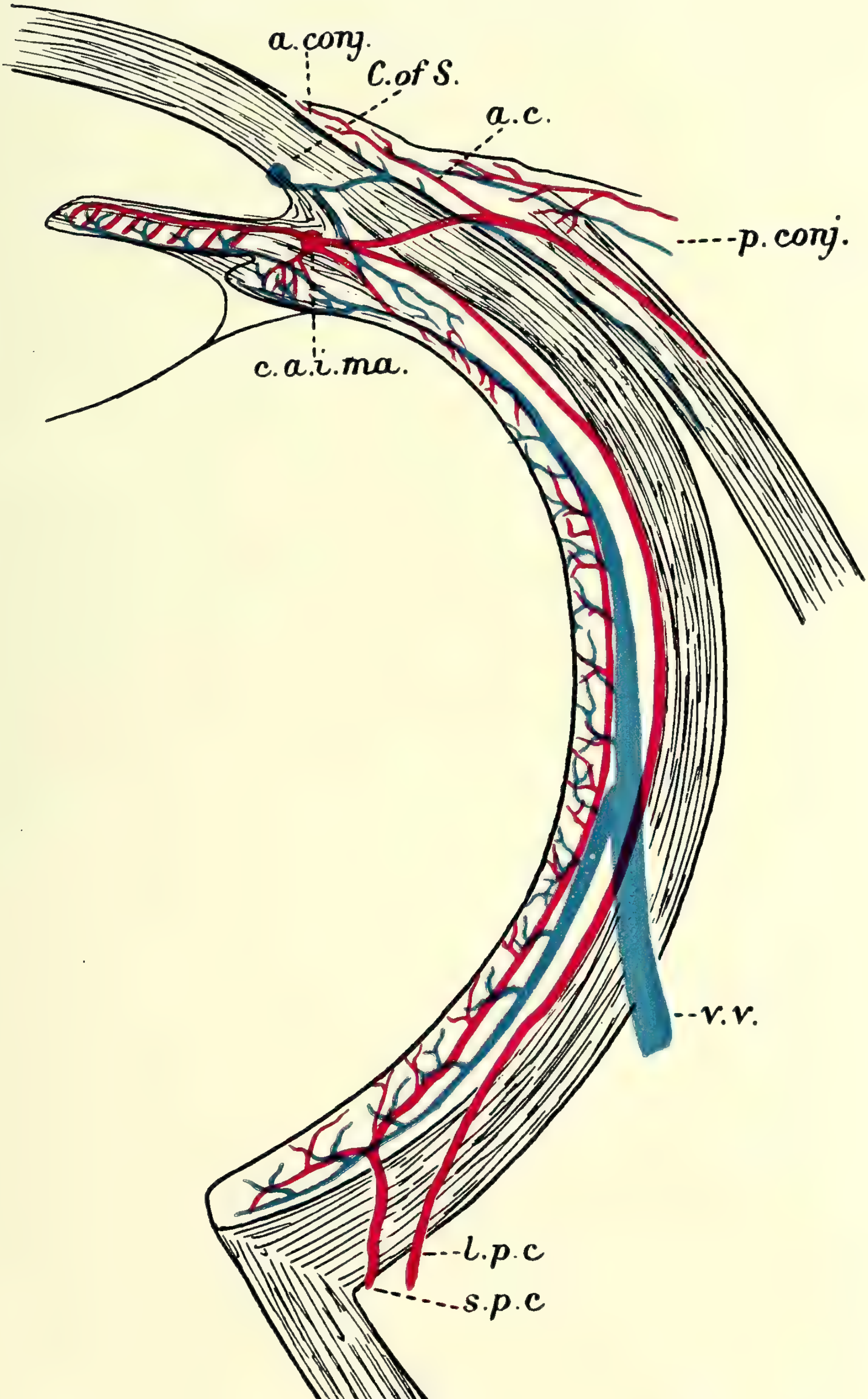
open into the ophthalmic vein. They enter the sclerotic rather behind the equator of the globe, two above and two below: they pass very obliquely through the sclera. The anterior ciliary veins are smaller than the corresponding arteries, since they receive blood only from the outer part of the ciliary muscle.

Of these ciliary vessels the short posterior ciliary arteries supply the whole of the choroid, being reinforced anteriorly by anastomosis with recurrent branches from the ciliary body. The ciliary body and iris are supplied by the long posterior and anterior ciliary arteries. The blood from the whole of the uveal tract, with the exception of the ciliary muscle, normally leaves the eye by the venæ vorticosæ only.

The two long posterior ciliary arteries pass forwards between the choroid and the sclerotic, without dividing, as far as the posterior part of the ciliary body. Here each divides into two branches (Fig. 6): they run forwards in the ciliary muscle, and at its anterior part bend round in a circular direction, anastomosing with each other and thus forming the circulus arteriosus iridis major. This is situated in the ciliary body at the base of the iris: from it the ciliary processes and iris are supplied. Other branches from the major arterial circle run radially through the iris, dividing dendritically and ending in loops at the pupillary margin. A circular anastomosis takes place a little outside the pupillary margin, the circulus arteriosus iridis minor.

The tributaries of the vorticose veins, which receive the whole of the blood from the choroid, are arranged radially, the radii being bent, so as to give a whorled appearance—hence their name. The veins of the iris are collected into radial bundles which pass backwards through the ciliary body, receiving tributaries from the ciliary processes. Thus reinforced, they form an immense number of veins running backwards parallel to each other through the smooth part of the ciliary body. After

PLATE II.



reaching the choroid they converge to form the large anterior tributaries of the vorticose veins. The veins from the outer part of the ciliary muscle on the other hand pass forwards and unite with others to form a plexus, part of which is the so-called canal of Schlemm. These vessels drain into the anterior ciliary veins. The marginal loops of the cornea and the conjunctival vessels are branches of the anterior ciliary (Plate II.).

CHAPTER II.

PHYSIOLOGY.

In order that the eye may satisfactorily perform its duties as an organ of vision it is essential that a sharp image of objects in the outer world shall be formed upon This/ the retina, ~~which~~ is effected by means of a series of curved surfaces, and the curvature of these surfaces and their relative positions to each other must be kept constant. For this purpose it is necessary that the walls of the globe should be kept stretched.

If a small cannula connected with a narrow-bored mercury manometer is pushed into the anterior chamber or into the vitreous of an animal it will be found that the mercury in the manometer will rise about 25 or 30 mm. (Fig. 7). In other words, the contents of the eyeball, which are for the most part fluid, exert a pressure upon the inner side of the walls which is about 25 mm. of mercury greater than the atmospheric pressure which falls upon the outside of the walls ; the walls are thus kept well stretched.

This pressure inside the eye is called the intraocular pressure, or the *tension*, of the eye. (These terms are used indiscriminately, though it is not quite accurate to do so.) In order that the tension of the eye may be kept up, work must be done by the organism, and a moment's consideration will make it evident that the source of energy must be the blood pressure. This conjecture has been proved conclusively true by experiments on animals, in which it is

found that the intraocular pressure follows passively ~~every~~ change in the general blood pressure (Fig. 8). [illegible] /the /s

It is obvious that it must be the fluid constituent of the contents of the globe which keeps up the internal pressure. This fluid fills the anterior and posterior chamber and permeates the vitreous. It is comparable to the lymph which bathes the tissues in other parts of the body, and it is indeed the lymph of the eye. In other parts of the body the chief function of the lymph is to carry food material to the tissue cells, and to carry away the effete products of the cell metabolism. It has a further function of keeping up the normal tissue tension. Both of these functions attain an unusual degree of importance in the case of the eye. We have already seen the necessity for keeping up the normal tension of the eye. As regards the nourishment of the cells, our review of the anatomy of the eye has shown that there are large areas, notably the whole of the lens and the vitreous, which possess no blood supply. They are dependent entirely for their nutrition upon the lymph.

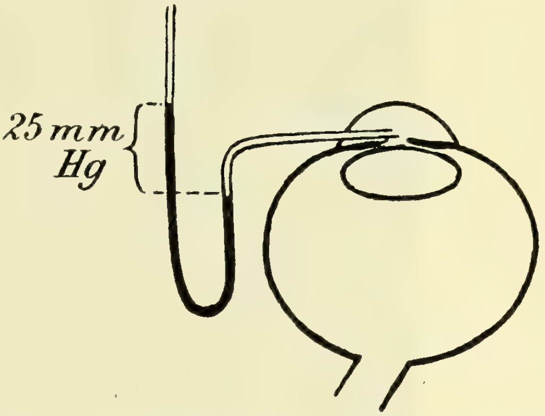


Fig. 7.—Diagram of manometer placed in communication with anterior chamber, showing that the normal intraocular pressure is about 25 mm. of mercury.

If water were to be forced into an impermeable elastic bag, the internal pressure might be kept indefinitely above the pressure upon the outside of the bag. Such an arrangement for keeping up the intraocular pressure would be unsatisfactory owing to the function of the lymph in nutrition. The stagnant fluid would soon lose all its food material, which would be used up, and it would become loaded with the excreted products of the cells, which would have a very deleterious effect upon them. Hence it

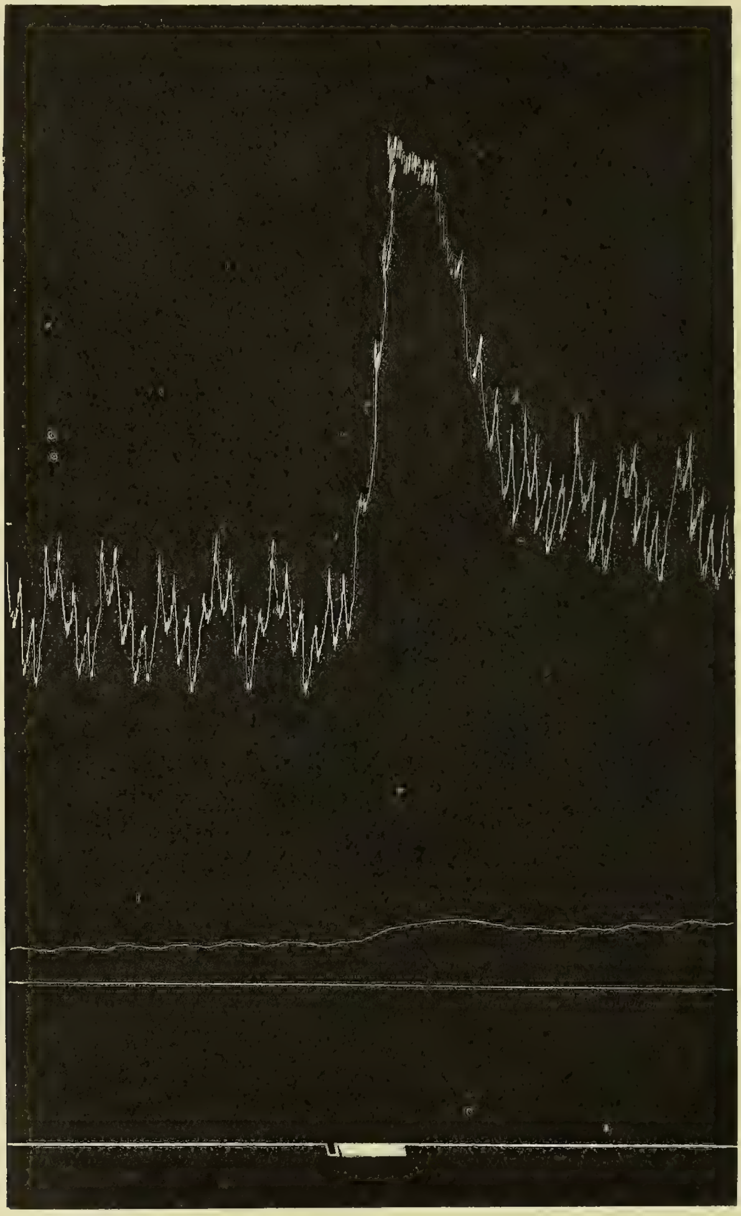


FIG. 8.—Tracing of right carotid blood pressure, intraocular pressure from canula in anterior chamber of left eye of a dog, which was fully under the influence of morphia, A.C.E. mixture, and curare. Stimulation of the vasomotor centre, showing that the intraocular pressure follows passively all the changes in the general blood pressure as produced by Traube-Hering curves and constriction of the arterioles of the splanchnic area.

is essential that the lymph shall be constantly renewed. This occurs in the eye. The lymph is continually being

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Though the process is essentially ~~—~~ a filtration it is not to be expected that membranes covered with living endothelial & epithelial cells will behave like dead inert membranes. That these cells exercise a selective activity is shown by the fact that whilst certain substances, e.g. agglutinins & [illegible], are allowed to pass freely, others, such as [illegible] & haemolysins, precipitins, do not pass into the aqueous. There is therefore justification for the use of the term secretion.

renewed, but at the same time it is equally rapidly being removed, and thus the amount present is kept constant.

It has been shown that in other parts of the body lymph is formed by filtration out of the capillaries: the amount poured out and its chemical composition are dependent upon the difference in pressure on the two sides of the filtering membrane, *i.e.*, the capillary wall. On the one side there is the relatively high intracapillary pressure, on the other the low tissue tension. Exactly the same is found to be the case in the eye. Here the intracapillary pressure is higher than in other parts of the body, but the extracapillary pressure is also higher than usual, being as much as 25 mm. of mercury, *i.e.*, the intraocular pressure. The difference between the two pressures is, however, less in the eye than elsewhere. Consequently we may expect to find on the one hand that the amount of lymph produced in a given time is small, and on the other hand that its chemical composition will differ materially from that of lymph elsewhere. Both these conjectures have been substantiated. The rate of production is so slow that it probably takes nearly an hour for the aqueous in the anterior chamber to be renewed. The chemical composition of the aqueous is consistent with the view that filtration is going on at a small difference of pressures, for under these circumstances we shall expect very little of the large-moleculed proteids of the blood to be able to get through the capillary wall. As a matter of fact the aqueous contains excessively little proteid (0·045 per cent.). In spite of the fact that the conditions of the production of aqueous are consistent with the view that it is a simple process of filtration, it is more generally spoken of as a secretion.

We have already noticed the resemblance of the ciliary processes to the glomeruli of the kidney. It is always dangerous to deduce physiological function from anatomical structure alone, but in the case of the ciliary body experiment and clinical and pathological observation alike confirm the conjecture that the processes are the chief if not the only site of the production of the aqueous in the human eye. If the iris and ciliary body are removed, as can be done in the rabbit without immediate destruction of the eye, no more aqueous is formed and the eye rapidly becomes soft and shrinks. That the effect is not due to the absence of the iris is shown by the fact that the iris is sometimes almost completely absent as a congenital defect, yet the aqueous is normally secreted. We may therefore conclude that the aqueous is "secreted" by the ciliary processes.

The greater part of the lymph thus produced passes into the posterior chamber. Thence it passes forwards through the pupil into the anterior chamber, the free communication between the two chambers being facilitated by the perpetual movements of the iris. A small quantity—not more than one-fiftieth part—of the aqueous secreted by the ciliary body passes backwards into the vitreous, which it nourishes. Situated in the vitreous, running directly forwards from the optic disc almost as far as the posterior pole of the lens, is a small tubular lymph space, the canal of Cloquet. It is the lymph space which originally surrounded the fœtal hyaloid artery; it persists after the latter disappears. The lymph of the vitreous finds its way into this space, which communicates with the perivascular lymph spaces surrounding the central vessels of the retina. By this route the lymph passes out of the eye through the optic nerve into the vaginal space. Only a very small proportion of the lymph produced by the ciliary processes, as mentioned—probably not a fiftieth part—finds its exit from the eye here. What becomes of the remainder? We have already said that it passes

forwards into the anterior chamber. It was at one time thought that it transuded through the cornea and escaped into the conjunctival sac. This is not so : it is now known that it filters away through the angle of the anterior chamber into the venous plexus which is called the canal of Schlemm. Having passed into the canal of Schlemm the effete lymph is carried away by the anterior ciliary veins.

It might be expected that so vascular a tissue as the choroid is concerned in the production of lymph. It is probable, however, that it produces only sufficient to nourish its own tissues and the outer layers of the retina. The retinal capillaries extend no deeper into the retina than the outer reticular layer; consequently the rods and cones and the pigment epithelium are dependent upon the choroid for their nutrition. The choroidal lymph passes out of the eye chiefly by way of perivascular lymph spaces around the vorticose veins, a small quantity passing into the subchoroidal space and so into the lymph sheaths of the posterior ciliary vessels. The retinal lymph passes away by perivascular lymph sheaths through the optic nerve into the vaginal space. The retina and choroid, then, only produce a sufficiency of lymph for their own requirements, and have nothing to do with sustaining the intraocular tension.

Similarly it might be thought that the vascular iris provided some of the aqueous. It is not easy to disprove this hypothesis, but it is easy to show that the iris is to some extent concerned in absorption, and it is highly improbable that the same structure carries on such opposite functions.

It has already been stated that sharp images of external objects must be formed upon the retina if the latter are to be seen clearly. Before considering how this is effected it will be advisable to refresh the reader's memory upon the elementary principles of optics. I would seriously impress upon the student that success in the diagnosis, and hence in the treatment, of diseases of the eye is impossible if such elementary principles of optics as are set forth here are not thoroughly mastered.

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¶ If white light such as sunlight is passed through a suitable prism or diffraction grating a spectrum is formed consisting of rays differing from each other in wave-length. Of these certain are visible & ~~[illegible]~~ appear to the majority of people as pure colours, viz. red, orange, yellow, green, blue, violet in the order named, the red having the longest, the violet the shortest wave-length. The visible spectrum extends from about 723 μμ at the red end to 397 μμ at the violet end, or roughly from 700 μμ to 400 μμ. Beyond the red end are ~~so-called~~ infra-red rays of greater length which cause a rise in temperature & are commonly known as heat rays. Beyond the violet end are waves of smaller length, the ultra-violet rays, which are capable of exciting chemical action. The longer visible rays also cause a rise in temperature & the visible rays are also actinic, though less so than the infra-red & ultra-violet rays respectively. Glass absorbs ~~many~~ some of the heat rays & many of the ultra-violet. Prisms & lenses made of quartz allow most of the ultra-violet rays to pass unimpeded. The media of the eye are uniformly permeable to the visible rays between 650 μμ & 390 μμ. With regard to ultra-violet rays the cornea absorbs all rays beyond 295 μμ, the lens all rays beyond 350 μμ, [illegible] absorption band with its maximum [illegible] can therefore reach the 275 μμ. Rays between 400 μμ & 350 μμ can reach the retina in the lens, those between 400 μμ & 295 μμ can reach the [illegible] retina in the aphakic eye. [illegible] the possibility of pathological changes resulting. Sunlight at the lower sea-level is poor in ultra-violet rays which fall off rapidly in intensity beyond 290 μμ. Ordinary glasses used for spectacles absorb rays ~~[illegible]~~ beyond 350 μμ. Heat radiation from 1100 μμ to 700 μμ passes into the eye & almost [illegible] a large amount of it reaches the retina (Hartridge & Hill). The pigment epithelium on the back of the iris absorbs heat radiation of all wave-lengths, & the same is probably true of the retinal epithelium at the back of the eye.

CHAPTER III.

ELEMENTARY OPTICS.

It is a familiar fact that a candle flame emits light in all directions. The light is transmitted in straight lines, so that we may imagine the light coming from the candle as consisting of an immense number of straight lines, all intersecting in some part of the flame. If we consider a minute point in the flame, then all the straight lines which cross in this point may be said to diverge from it. Each of these hypothetical straight lines is called a ray.

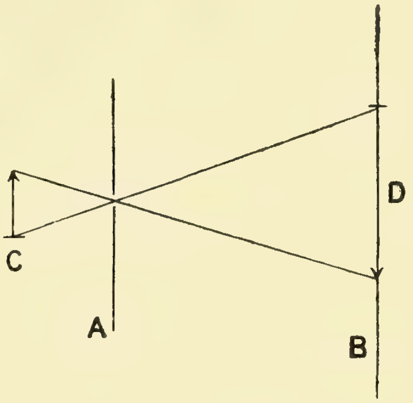

Fig. 9.

Now, every point on such a ray represents, or is the image of, the point of light from which it springs. This is shown very clearly by a simple experiment carried out in a dark room. Make a pinhole in a piece of cardboard (Fig. 9, A), and hold the cardboard in front of the candle (C) at a little distance from it. Beyond the cardboard hold up a white screen (B), so that the cardboard is between the screen and the candle. A dim image (D) of the flame will be thrown upon the screen, and it will be noticed that it is upside down, *i.e.*, an inverted image of the flame is formed. This is due to the fact that the cardboard cuts off all the rays of light from the candle except such as can pass through the hole. The only rays from the top of the flame which can pass through the hole are those which are caught upon the lower part of the screen. They represent the top of the flame; hence they reproduce its shape accurately. The image is very dim because only a few rays of light can pass through the small hole. Now make another hole a little distance away from the first. Another inverted image of the flame is seen. If a dozen holes are made, a dozen images appear. If two holes are very close together the images will overlap. If a large hole is made, so many images overlap that all resemblance to the original flame is lost, and part of the screen becomes uniformly illuminated. If we take away the cardboard altogether the whole screen becomes illuminated, and we now know that this is because we have an infinite number of images of the flame all overlapping each other.

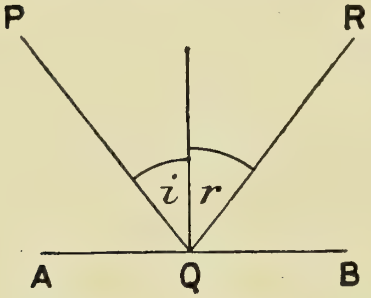

FIG. 10.—The ray from P which strikes the mirror AB at Q is reflected to R, so that PQ and QR are in the same plane, viz., that of the paper, and the angle of incidence, *i*, is equal to the angle of reflection, *r*.

Light travels with different velocities in different media. If the velocity is less in one medium than another the first medium is said to be optically denser than the second.

When light, travelling in one medium, meets another medium it breaks up into two parts: part is *reflected* back into the first medium; part is *refracted* into the second medium. If the second medium is opaque none of the light is refracted.

REFLECTION.

Let us now consider what happens to a ray of light when, travelling in one medium, it is reflected from the surface of a denser medium. We have already said that its direction is altered. Before it meets the surface it is called an incident ray; after it leaves the surface it is

called the reflected ray. If a line is drawn at right angles to the surface at the point where the incident ray meets it, it is found to be an invariable rule that the incident ray makes the same angle with this line, which is called the normal, that the reflected ray makes with it. Put in formal language, this law of reflection is that *for all surfaces the angle of incidence is equal to the angle of reflection, and is in the same plane with it* (Fig. 10).

Plane Mirrors.—Let us apply this rule to an ordinary flat mirror (Fig. 11). If P is a luminous point in front of the mirror AB, the ray PQ will be reflected towards R, and the ray PS towards T; *i.e.*, the reflected rays QR and ST appear to come from *p*, a point as far behind the mirror as P is in front of it. As the rays QR and ST have to be produced backwards in order that they may meet, no real image is formed, and such an image is called a virtual image. Note that the rays reflected from a plane mirror are divergent. The same reasoning holds good for every point on the object PV, its image being *pv* as far behind the mirror as the object is in front of it: moreover, the size of the image is equal to that of the object.

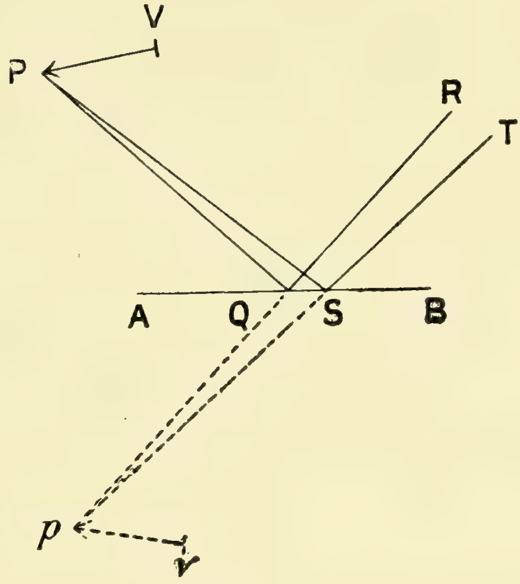

FIG. 11.

Concave Mirrors.—Here the normal to the surface is the radius of the sphere. If AH (Fig. 12) is part of the section of a concave mirror and PB is an object, K being the centre of the sphere, then the line HKB is called the axis, and H the apex of the mirror. The ray PK through the centre of the sphere will obviously be reflected along itself, so that the image of P must be on PK. The ray PA, parallel to the axis, will meet PK in *p*. Hence *p* is the image of P. Now it is found that all rays parallel to the axis and not very far removed from it cut the axis in the same point, F, and this point bisects the line HK. This point is called the principal focus of the mirror. If the object PB were removed a very great distance away from the mirror, all the rays which fell upon a small portion of the mirror near H would diverge so little from each other that they would all be practically parallel to BH, and the image of PB would be extremely small and situated at F. In each of these cases the image is an inverted one of the object.

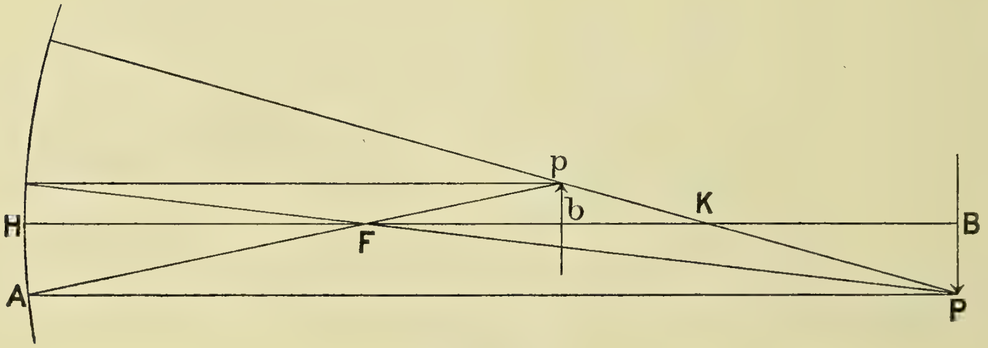

FIG. 12.

It is an axiom of optics that the direction of the rays is reversible. Hence, if *pb* were an object, it would have its image at PB, and if there were an object at F, all the rays from it reflected by the mirror would be parallel to the axis, and the image would be infinitely large and situated at infinity.

What would happen if the object were situated between F and H? In that case (Fig. 13) the rays would diverge after reflection as if they came from an object behind the mirror, much as they do with a plane mirror. The image would therefore be a virtual one, situated behind

the mirror: it would be erect and larger than the object.

The important fact to remember with regard to concave mirrors is that if the object is farther away from the mirror than its focal distance, *i.e.*, than half its radius of curvature, the image is a real inverted one situated also in front of the mirror. This is the condition which is almost always present in the ordinary use of ophthalmic instruments.

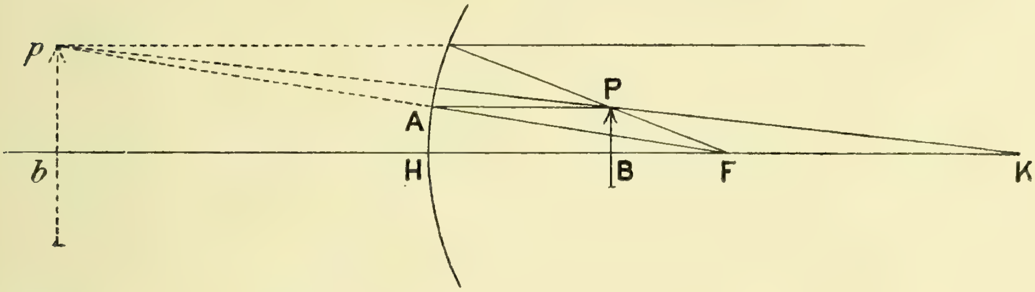

FIG. 13.—The ray from P parallel to the axis is reflected through F, the principal focus. The ray FP is reflected parallel to the axis. The ray KP is normal to the surface, and is therefore reflected on itself. Any two of these rays will give the situation of *p*, the image of P.

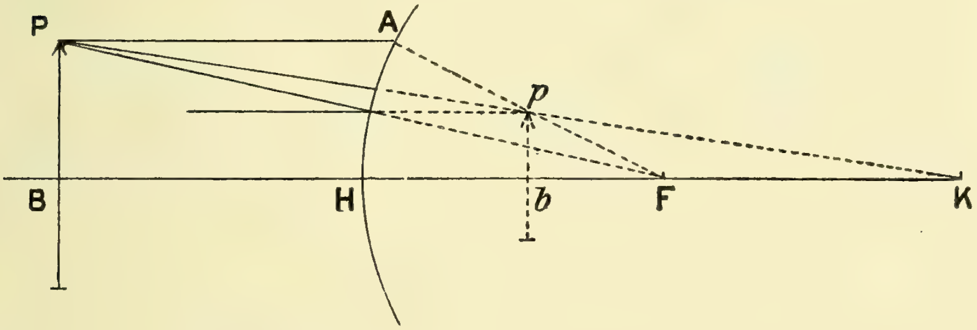

FIG. 14.—Reflection by a convex mirror. The description of Fig. 13 applies equally to this case.

Convex Mirrors.—We are not accustomed to use convex mirrors in ophthalmic instruments, but it is necessary to know what happens with them since the cornea acts as a convex mirror. Here, as will be seen from Fig. 14, the image is always virtual, erect, and smaller than the object. As with the concave mirror, if the object is a long way off, the image will be situated at the principal focus, *i.e.*, at a distance equal to half the radius of curvature behind the mirror.

REFRACTION.

We have now to consider what happens to the refracted ray when the incident ray, travelling in one medium, *e.g.*, air, meets an optically denser medium, *e.g.*, glass. We have already said that the light will now travel more slowly. It follows directly from this fact that it will be deviated towards the normal to the surface, and it will be more deviated the greater the difference in optical density between the two media. If the density of air is taken as unity, then the ratio of its density to that of the second medium is called the *index of refraction* of the medium.

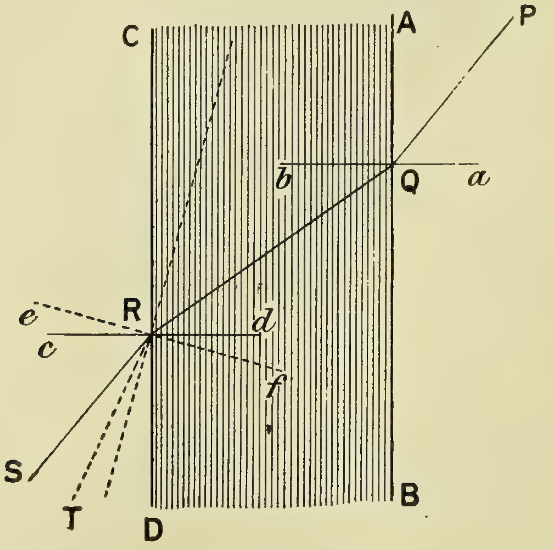

FIG. 15.—Refraction by a plane lamina.

Plane Lamina.—Let us see what happens when an incident ray, such as PQ (Fig. 15), meets the surface of a plate of glass with parallel sides. It will be deflected towards the normal, *ab*. When the ray passes out of the glass on the other side, it will obviously be deflected away from the new normal, *cd*, just as much as PQ was deflected towards it. Hence the emergent ray RS will be parallel to the incident ray PQ. If the plate of glass is very thin, RS will be practically continuous with PQ.

Prisms.—If we imagine one side (CD) of the plate in the last figure to revolve round R, we shall be able to understand the nature of refraction by a prism. QR will now make a larger angle with the new normal *ef* than it did with the old one *cd*. Consequently the angle of refraction will also be larger, *i.e.*, the new direction of the emergent ray will be RT. In other words, the ray is deviated towards the base of the prism.

The ray PQRS in Fig. 16 is said to pass symmetrically through the prism. Under these circumstances, if the prism is made of crown glass, the deviation of the ray is approximately equal to half the refracting angle of the prism, *a*.

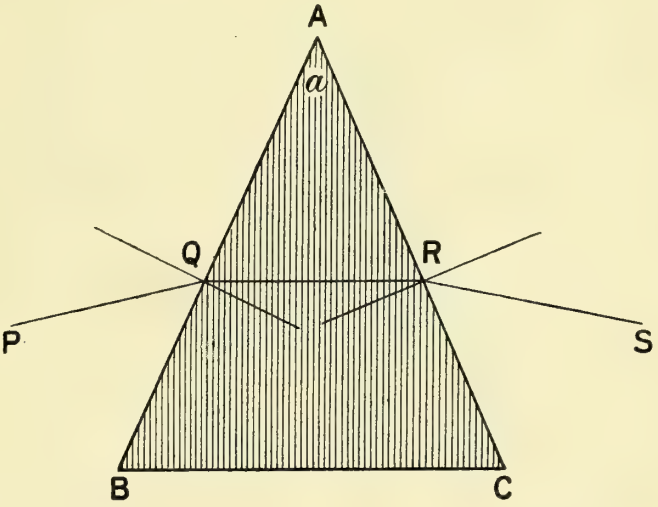

FIG. 16.—Refraction by a prism.

We are accustomed to project objects along the direction of the rays of light as they enter the eye, and in doing so we ignore the effect of refraction since it enters relatively little into our everyday experience. If, therefore, we look at a candle P through a prism, as in Fig. 17, the light will appear to come from *p*. Objects, then, seen through a prism, appear displaced towards the apex of the prism.

Lenses.—Ordinary lenses are pieces of glass with spherical surfaces. The line passing through the centres of curvature of the surfaces is called the axis of the lens. Fig. 18 shows the chief varieties of lenses, viz., (1) biconvex, (2) biconcave, (3) plano-convex, (4) plano-concave,

(5) convexo-concave or meniscus: these names require no further explanation.

The effect of a biconvex lens upon rays of light meeting it, is very similar to what would occur if it were replaced by two prisms set base to base (Fig. 19).

If the incident rays are parallel to the axis they will be refracted in such a manner that they all cross the axis in a single point upon the other side of the lens. This point is called the principal focus of the lens, and its distance from the lens is called the focal distance or length of the lens. When the lens has the same medium, *e.g.*, air, on each side of it, the two principal foci, one on each side of the lens, are situated at equal distances from it. For thin glass lenses of low power the focal distance is equal to the radius of curvature of the two surfaces when these are equally curved. If there is an object a very long distance away from the lens, the rays which come from it are practically parallel. Hence in this case an image of the object will be formed by the lens at its principal focus; it will be inverted and very small. If the object is gradually brought nearer and nearer to the lens (Fig. 20) the image will recede farther and farther from it; from being very small it will grow larger and larger, until, when the object is at the principal focus, the image will have receded to infinity, and it will be infinitely large, *i.e.*, all the rays

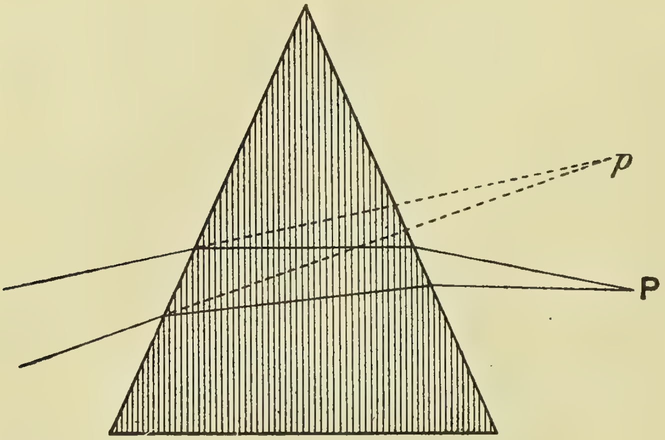

FIG. 17.—Displacement of objects seen through a prism. The object P appears to be situated at *p*.

coming from the object at the principal focus are parallel to the axis and to each other after refraction. If the object is brought still closer to the lens than its focal distance (Fig. 21) it will be found that its image is a virtual one behind the object, and that it is erect and larger than the object. The positions of the object and image bear a contant relationship to each other and are called conjugate foci.

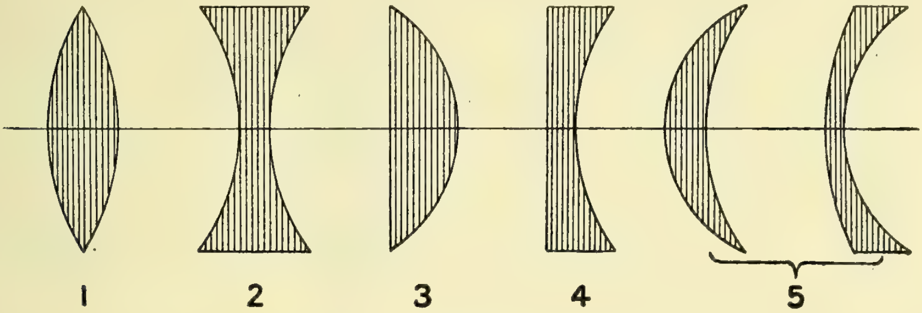

FIG. 18.—Types of lenses.

There is a point in the middle of a biconvex lens which is called its optical centre. With thin lenses any ray which passes through this point is practically not deviated at all. It is easy to understand why this is so. If PQRS (Fig. 22) is such a ray and tangents are drawn to the two surfaces at the points Q and R, these two tangents will be

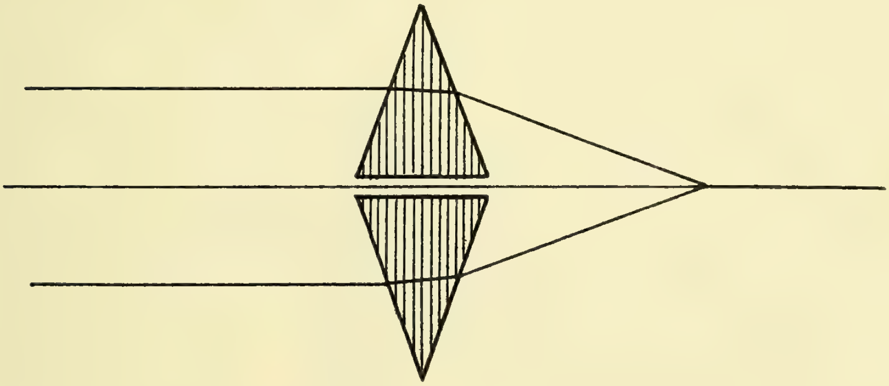

FIG. 19.

parallel to each other. Consequently, the lens acts for such a ray exactly as if it were a plate with parallel sides, and we have already seen that in such a case the emergent ray is parallel to its original direction. If the lens is very thin the refracted ray will be practically continuous with the incident ray.

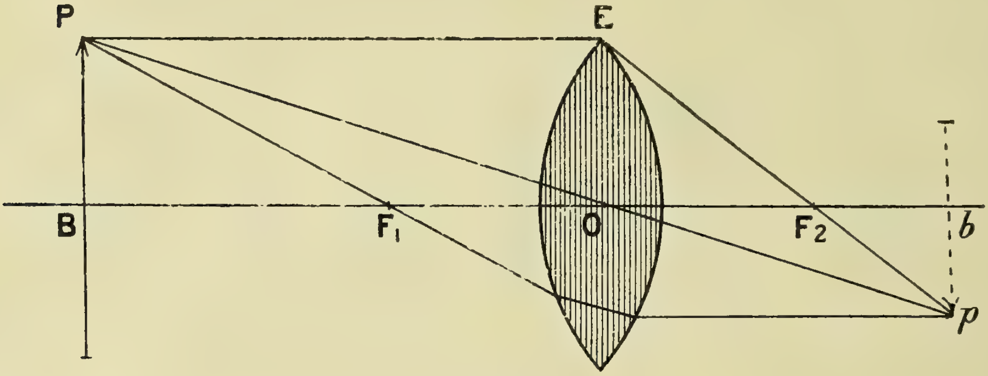

FIG. 20.—The ray PE, parallel to the axis, is refracted through the second principal focus F_2. The ray PF_1, through the first principal focus, is refracted parallel to the axis. The ray PO, through the optical centre of the lens, is not deflected. Any two of these rays gives the situation of *p*, the image of P.

If we know these facts, viz., that rays passing through the optical centre are not deviated, and that rays passing through the principal focus are parallel to the axis after refraction, we can easily construct the image of an object in any given position. Thus, in Fig. 20, if PB is an

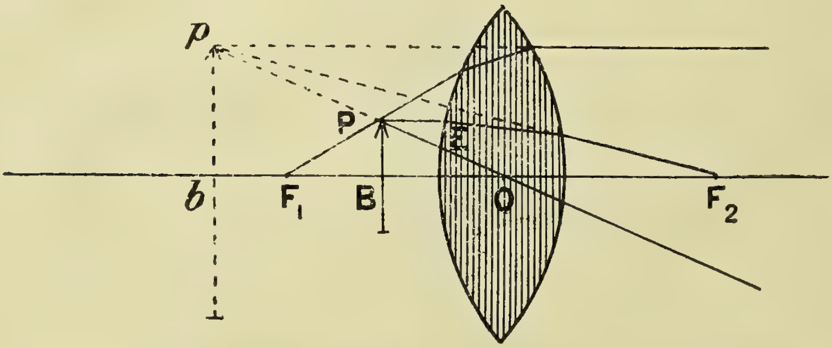

FIG. 21.—The description of Fig. 20 applies equally to this figure.

object, the ray PO through the optical centre O will not be deviated; the ray PE parallel to the axis will pass through the second principal focus F_2; and the ray PF_1 through the first principal focus will be parallel to the axis after refraction. Hence *pb* must be the image of PB.

The effect of a biconcave lens upon rays of light meeting it is very similar to what would occur if it were replaced by two prisms set apex to apex (Fig. 23).

Here, if the incident rays are parallel to the axis they will be divergent after refraction, and the amount of divergence of the individual rays will be such that if they are produced backwards they will all cross the axis in a single point upon the same side of the lens that they came from. This and the corresponding point on the other side of the lens are called the principal foci. The biconcave lens also has an optical centre, situated upon the axis within it and having the same properties as in the case of the convex lens. The image of any object formed by a concave lens can be constructed in exactly the same manner as for a convex lens (Fig. 24). It will be found that in every position of the object the image is always virtual, erect and smaller than the object.

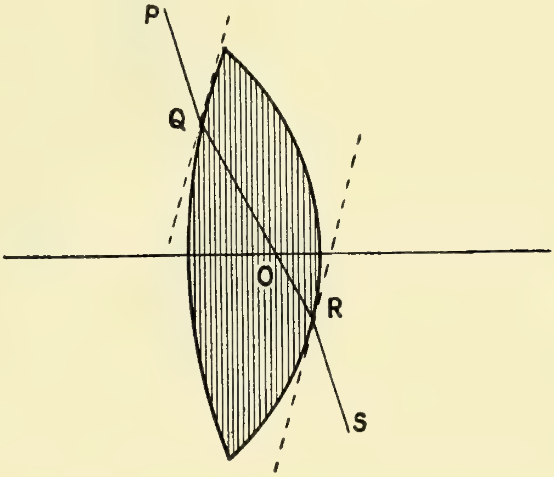

FIG. 22.—Properties of the optical centre of a lens.

Plano-convex and plano-concave lenses act like biconvex and biconcave respectively, but in them the optical centre is on the curved surface at the point where the axis cuts it. Menisci act as convex or concave lenses according as the convex or the concave surface has the greater curvature. In them the optical centre is outside the lens.

It will have been noticed that the refractive power of a lens varies inversely as the focal distance, *i.e.*, a lens with a short focal distance will bend the rays more than one with a longer focal distance. It is necessary to have some system of numbering lenses so as to indicate their refractive power. The most convenient system for ophthalmic purposes is that which takes a lens with a focal distance of 1 metre as a standard. Such a lens is said to have a refractive power of 1 *dioptre*. A lens with a focal length of half a metre will be twice as strong as one whose focal

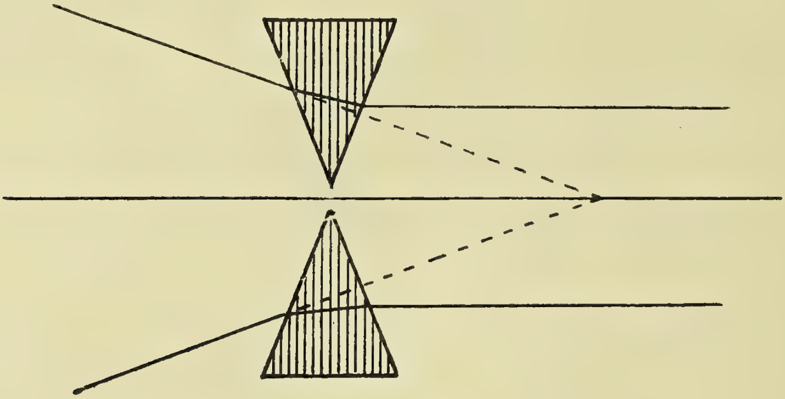

FIG. 23.

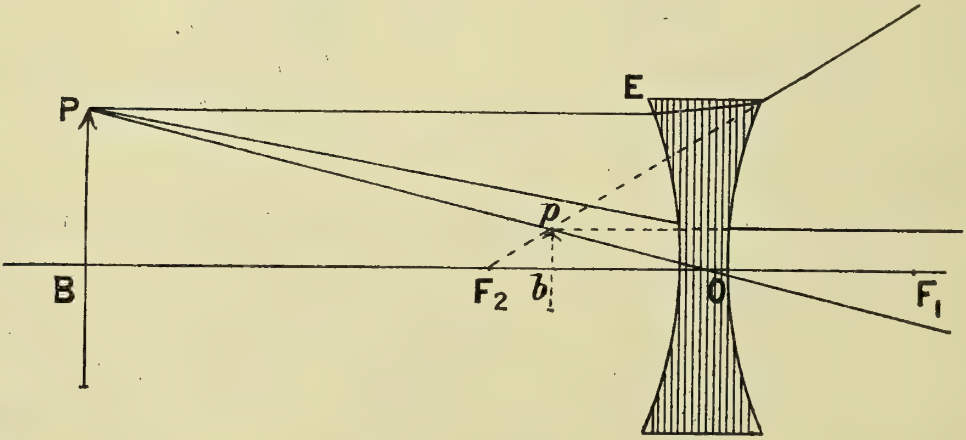

FIG. 24.—The description of Fig. 20 applies equally to this figure.

length is 1 metre: the refractive power of such a lens is therefore 2 dioptres. Similarly, a 3 D (3 dioptre) lens has a focal length of one-third of a metre, or 33 cm.; a 4 D lens, 25 cm.; and so on. It is important to remember that in this system the standard is a metre, not a centimetre or a millimetre; otherwise confusion may arise.

Lenses were formerly numbered according to their focal lengths measured in inches. Since the inch has a different value in different places, the method is unsatisfactory. Prescriptions for spectacles are, however, sometimes met with in this notation. They are easily transformed into the dioptric system by remembering that there are 40 inches (roughly, or 36 Paris inches) in 1 metre. Therefore a 40 inch lens = 1 D; a 20 inch lens = 2 D; a 4 inch lens $= \frac{40}{4} = 10$ D; and so on: a lens of focal length = 4 Paris inches $= \frac{36}{4} = 9$ D.

Convex lenses are indicated by a plus sign (+), concave by a minus (−) sign before the number.

Cylindrical lenses are also used in ophthalmology; their nature and use will be considered at a later stage.

The accompanying diagram (Fig. 25) indicates the usual arrangement of lenses, &c., in the trial case.

We often wish to find out whether a lens is convex or concave, and what its refractive power is. There are several ways of doing this, but the simplest is with the assistance of the trial case. Hold a convex lens up near the eye and look at distant objects through it; then move the lens a little from side to side: the distant objects will seem to move in the opposite direction to that in which the lens is moved. If we repeat the process with a concave lens the objects seem to move in the same direction as the lens. The reason is to be found in the fact that a convex

<table>
<tr><th colspan="2">Duplicate Sets of Convex Spheres from + 0·25 D to + 20 D</th><th colspan="2">Duplicate Sets of Convex Cylinders from + 0·25 D to + 7 D</th><th colspan="2">Duplicate Sets of Concave Cylinders from − 0·25 D to − 7 D</th><th colspan="2">Duplicate Sets of Concave Spheres from − 0·25 D to − 20 D</th></tr>
<tr><td colspan="2" rowspan="3">etc.</td><td colspan="2">etc.</td><td colspan="2">etc.</td><td colspan="2" rowspan="3">etc.</td></tr>
<tr><td>+ 0·75
+ 0·5
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<tr><td colspan="4">Prisms.</td></tr>
<tr><td rowspan="2">+ 2
+ 1·75
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+ 1·25
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+ 0·25</td><td rowspan="2">+ 2
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+ 1·5
+ 1·25
+ 1·0
+ 0·75
+ 0·5
+ 0·25</td><td colspan="4">Coloured Glasses, &c.</td><td rowspan="2">− 2
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</table>

FIG. 25.—Diagram of the arrangement of lenses, &c., in a trial case.

lens forms an inverted, whilst a concave forms an erect image. If we place two lenses of opposite sign but equal curvature in contact with one another the combination will make a plate with parallel sides: such a plate, as we know, does not practically deflect the rays of light at all. Hence we can determine the strength of a lens by exactly neutralising it with a lens of the opposite sign out of the trial case. Let us take a concrete example, a particular lens which we wish to determine. We hold it up and find that distant objects seem to move in the opposite direction to the lens. We know that it is a convex lens. We then put a weak concave lens in contact with it and repeat the process. We find that with a − 2 D lens objects still seem to move in the opposite direction, though not so much. With a − 3 D lens there is only a trace of movement, and with a − 3·5 D lens there is no movement at all. We conclude that the original lens was + 3·5 D. In performing this test it is important to have the two lenses as closely in contact as possible, and also to have their centres in contact. If the centre of one lens is higher than that of the other they will obviously not counteract each other exactly. If they are not in contact the result will be either too high or too low.

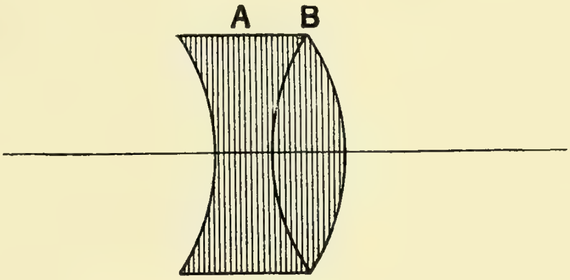

FIG. 26.

When the lenses are in contact the refractive power of the combination (D) is equal to the algebraical sum of the refractive powers of the two lenses (d_1, d_2): *i.e.*, $D = d_1 + d_2$, or $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$ where F, f_1, f_2, are the respective focal distances (Fig. 26).

Suppose, however, that two convex lenses are separated by a distance c (Fig. 27). The lens A will make parallel rays converge towards a, but after a distance c they meet the lens B : hence the convergence of the rays is not expressed by $\frac{1}{f_1}$, but by $\frac{1}{f_1 - c}$. Therefore the combined effect of the lenses, D, or $\frac{1}{F}$, is now equal to $\frac{1}{f_1 - c} + \frac{1}{f_2}$.

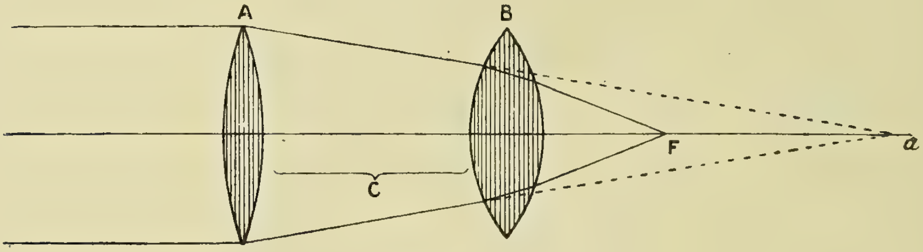

FIG. 27.

If the second lens (B) is a concave one (Fig. 28) its effect will be one of divergence, so that it must have a negative sign, and D will now be equal to $\frac{1}{f_1 - c} - \frac{1}{f_2}$.

Examples : (1) $f_1 = 333$ mm. ; $f_2 = 250$ mm. ; $c = 133$ mm.

$$\text{Then } \frac{1}{F} = \frac{1}{333 - 133} + \frac{1}{250} = \frac{1}{111}.$$

That is, the combination of a + 3 D lens with a + 4 D, separated

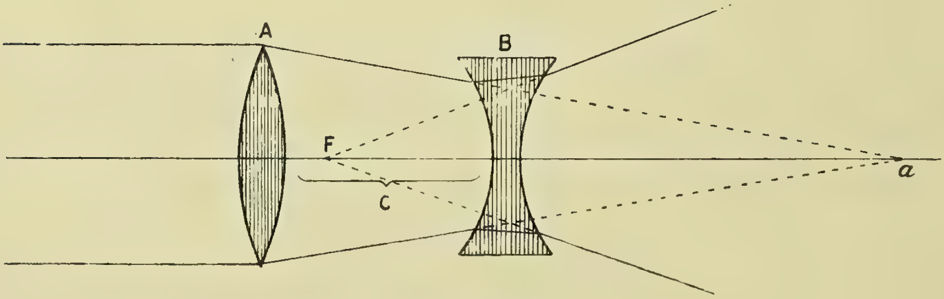

FIG. 28.

by a distance of 133 mm., will be that of a + 9 D lens, instead of + 7 D if they had been in contact.

(2) $f_1 = 333$ mm. ; $f_2 = -83$ mm. ; $c = 133$ mm.

$$\text{Then } \frac{1}{F} = \frac{1}{333 - 133} - \frac{1}{83} = -\frac{1}{142}.$$

That is, the combination of a + 3 D lens with a − 12 D, separated by a distance of 133 mm., will be that of a − 7 D lens, instead of − 9 D if they had been in contact.

b. 7 [illegible] has a very much stronger optical effect than the crystalline lens!

CHAPTER IV.

ELEMENTARY PHYSIOLOGICAL OPTICS.

The eye as an optical instrument very much resembles an ordinary photographic camera. The latter consists of a dark chamber with an aperture in front containing a strong convex lens, and with a movable back behind. The effect of the lens is exactly like that shown in Fig. 20. PB will represent the object to be photographed; the movable back is adjusted so that it occupies the position of *pb*, in which case a sharp image of the object will be thrown upon the ground glass which forms the back. The ground glass is then replaced by a sensitive plate, and the photograph is taken.

In the eye the retina corresponds with the sensitive plate. Instead of having only one lens in the front aperture, represented by the crystalline lens, there is also a curved plate with parallel sides, the cornea, which acts ~~very much~~ like another lens. The object of this more complicated arrangement is to shorten the focal distance of the system, so that the eye may be shorter and more compact.

From this analogy we see that the eye, from the optical point of view, acts like a strong convex lens. We have already stated that when a lens has the same medium on each side of it the anterior and the posterior focal distances are equal to one another. This is not the case in the eye. Here the medium in front is air, whilst behind the lens there is the vitreous, which has a higher refractive index, rather more than that of water. Hence the anterior and posterior principal focal distances are not equal, the anterior being about 13 mm. in front of the cornea, and the posterior about 23 mm. behind it.

The cornea has about the same optical density or refractive index as the aqueous, which is also equal to that of the vitreous. The anterior surface of the cornea may be regarded as nearly spherical, the radius of curvature being 8 mm. The centres of curvature of the cornea and the two surfaces of the lens are all on the same straight line, which is called the *optic axis*. When a ray of light meets the cornea (Fig. 29) the ray will be deflected towards the normal, *i.e.*, towards the radius drawn through the point of incidence. It will pass through the layers of the cornea in the new direction, and will also continue in the same direction through the aqueous, for, as we have said, the refractive index of the aqueous is the same as that of the cornea. When the ray meets the lens, which has a greater refractive index than the aqueous, it will again be deflected in the same sense, *i.e.*, towards the axis, upon which the cornea and lens are centred.

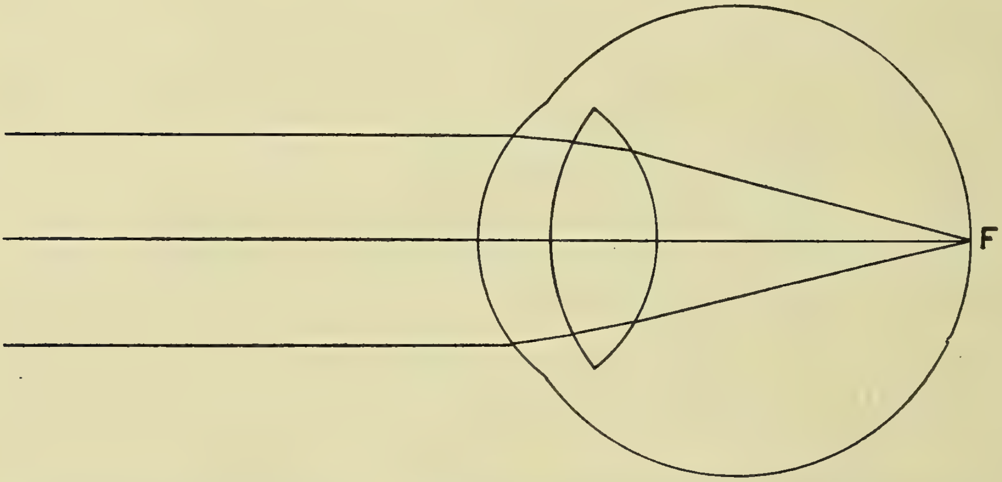

FIG. 29.—Emmetropic eye. Parallel rays are brought to a focus on the retina.

We have seen that in the case of a lens, and the same is true of any homocentric optical system, parallel rays

meet at the principal focus. Hence, if parallel rays fall upon the cornea, they will be brought to a focus 23 mm. behind it. Now, the rays which are emitted by a luminous body are divergent. If, however, the object is a long distance away, the individual rays in any small bundle will diverge so little from each other that they may be regarded as practically parallel. This is the case with the small bundles of rays which are able to enter the pupil of the eye. Hence, as in the case of a convex lens (*vide* p. 32), the image formed by the eye of these distant objects will be situated at the principal focus, *i.e.*, 23 mm. behind the cornea. But that is exactly the distance of the retina from the cornea in the normal eye. Hence we see that the normal eye in its condition of rest is so constituted that distant objects form their images upon the retina (Fig. 29).

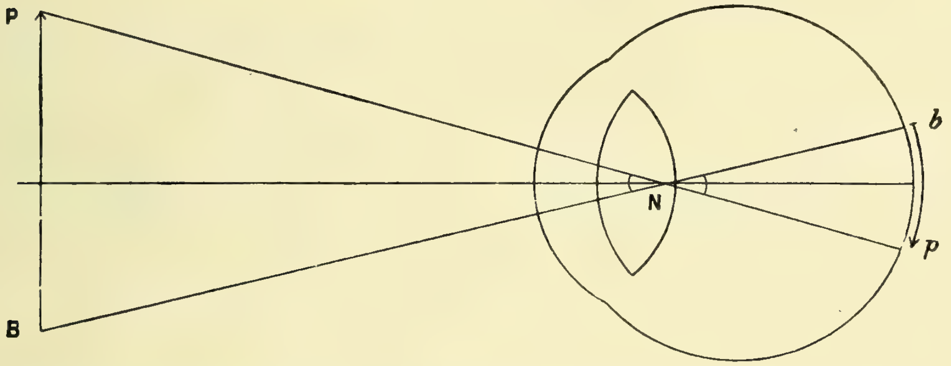

FIG. 30.—Nodal point of the eye, visual angle, and relative sizes of object and retinal image.

The optic axis, produced backwards to meet the retina, cuts it almost exactly at the fovea centralis. Hence, any distant object on the prolongation forwards of the optic axis will have its image at the fovea, which is the best spot for distinct vision.

We notice that, just as with a convex lens, the image is inverted. It is re-inverted psychologically in the brain.

It is easy to find the size of the retinal image which any external object will form since the eye possesses an optical centre, which, however, is usually called the *nodal point* (N), quite similar to the optical centre of the lens. In the eye this point is situated upon the optic axis near the back of the lens. As in the case of lenses any ray which passes through this point will not be deflected. If, therefore, there is an object PB (Fig. 30) in front of the eye, the size of its retinal image *pb* is found by joining the extremities of the object and the nodal point and producing these lines until they meet the retina. The lines will enclose an angle, PNB, which is called the *visual angle;* in other words, the angle subtended by the object at the nodal point is called the visual angle. It is of course equal to the angle *p*N*b*, which is subtended by the retinal image at the nodal point.

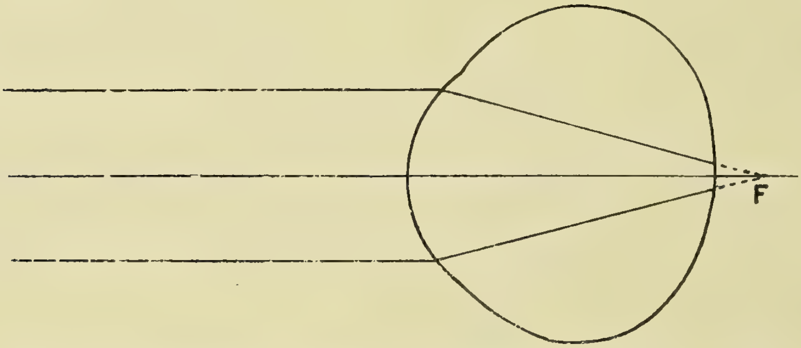

FIG. 31.—Hypermetropic eye. Parallel rays tend towards a focus behind the retina.

In some eyes the retina is not situated in exactly the right place for the images of distant objects to be clearly focussed upon it. It may be too far forward (Fig. 31), or too far back (Fig. 32); in the former case they are said to be hypermetropic, in the latter myopic. If we consider the effect upon parallel rays we shall see that in the hypermetropic eye they have not had space to come to a

focus, whereas in the myopic eye they have not only come to a focus, but have commenced to diverge. In each case a blurred image will be formed upon the retina, and vision will be impaired. Such conditions are called errors of refraction or *ametropia* (ἀ, privative, μέτρον, measure; not according to measure). In contradistinction to hypermetropia and myopia the normal condition is called emmetropia.

It has already been stated that in optics the direction of the rays is reversible. Let us imagine a minute point on the retina to be luminous. It will give out rays which will diverge in all directions. Some of these rays will meet the lens and cornea and pass out of the eye. Now, in the emmetropic eye, those rays which get through the pupil will have to submit to exactly the same optical deviations as the parallel rays falling upon the cornea did when they passed into the eye and came to a focus on the retina. Hence, on the principle of the reversibility of the rays, the rays coming from a point on the retina will be parallel to each other when they leave the eye (Fig. 29).

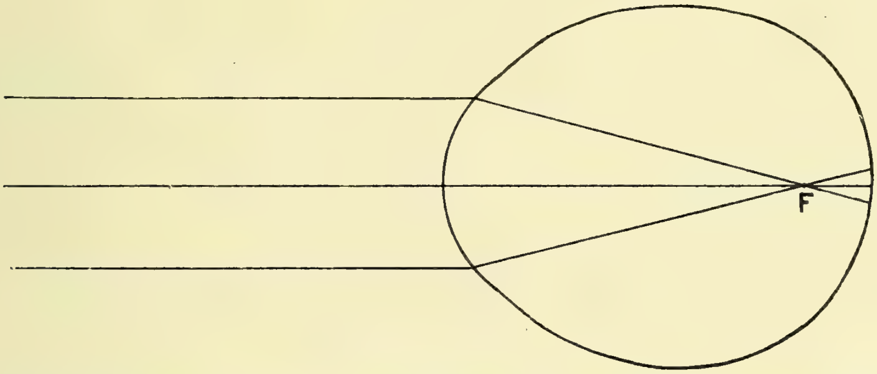

FIG. 32.—Myopic eye. Parallel rays are brought to a focus in front of the retina.

Suppose, however, that the eye is hypermetropic owing to being too short (Fig. 33). The rays coming from a point on the retina will not have had space to diverge so much from the axis as the corresponding rays of the emmetropic eye before they fall upon the back of the lens. (Compare the effect of placing an object closer to a convex lens than its principal focus (Fig. 21).) The lens and aqueous and cornea will therefore cause them to converge less than in the emmetropic eye. They will therefore still be divergent when they leave the eye, though of course not so divergent as when they were passing through the vitreous. In fact, their direction will be the same as if they came from a point behind the eye. The nearer the retina is to the lens, the more divergent they will be,

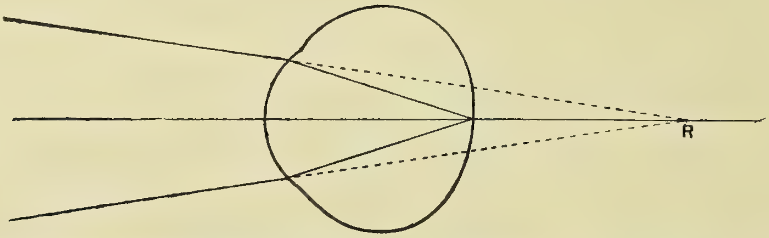

Fig. 33.—Hypermetropic eye. Rays from a point on the retina are divergent when they emerge from the eye, as if they came from the point, R, behind the eye.

and the nearer to the back of the eye will be the point from which they seem to come. This virtual point (R) behind the eye is called the *remote or far point* of the eye. The point on the retina and this point behind the eye are really conjugate foci (Fig. 33).

Suppose now that the eye is myopic owing to being too long (Fig. 34). The rays coming from a point on the retina will have become more divergent from the axis than the corresponding rays of the emmetropic, and still more divergent than those of the hypermetropic eye before they fall on the back of the lens. (Compare the effect of placing an object farther away from a convex lens than its principal focus (Fig. 20).) The refractive media in front will therefore cause them to converge more than in the emmetropic eye. They will hence be convergent when

they leave the eye, and will cross in a point (R) somewhere in front of the eye (Fig. 34). The farther the retina is from the lens, *i.e.*, the higher the degree of myopia, the more convergent they will be, and the nearer to the front of the eye will be the point where they cross. This point is again the conjugate focus to the point on the retina, but in this case it is a real point. It is also called the remote or far point of the eye.

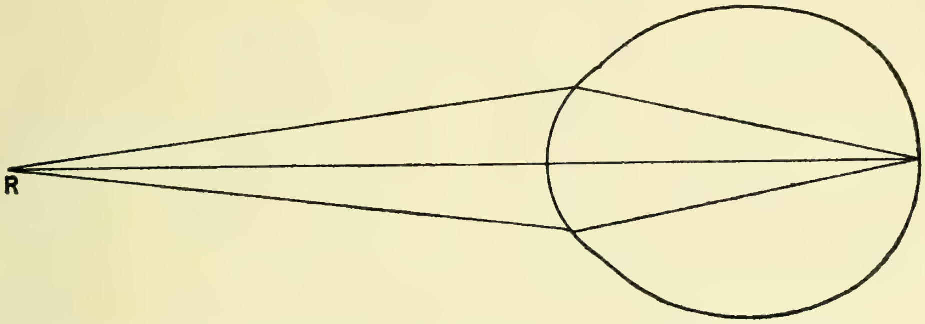

FIG. 34.—Myopic eye. Rays from a point on the retina are convergent when they emerge from the eye, so that they cross at a real point, R, in front of the eye.

Where then is the far point of the emmetropic eye?

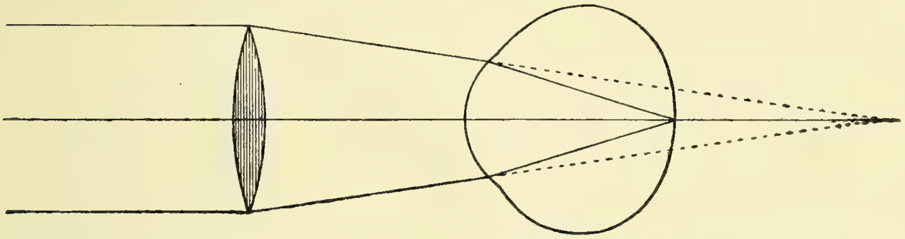

FIG. 35.—Hypermetropic eye. Parallel incident rays brought to a focus on the retina by means of a suitable convex lens.

We have seen that in each of the other conditions it is where the rays emitted from a point on the retina meet after emerging from the eye. In the emmetropic eye the emergent rays are parallel to each other. But parallel rays meet at infinity; therefore the far point of the emmetropic eye is at infinity.

It is obvious that, in hypermetropia, if we give the rays the requisite amount of convergence before they enter the eye they will be brought to a focus upon the retina. We can do this by placing a convex lens in front of the eye (Fig. 35). This is what is done by means of spectacles. The refractive or convergent power of a convex lens is the reciprocal of its focal distance. Hence in hypermetropia of 1 D, a convex lens of 1 D or 1 metre focal distance placed in contact with the cornea will direct parallel rays towards a point 1 metre behind the eye, *i.e.*, to the far point of the eye. Such a lens acting in combination with the refractive force of the eye would bring the rays to a focus on the retina. But lenses cannot be worn in contact with the cornea. If the lens is placed 20 mm. in front of the cornea its focal length will have to be 1,020 mm. instead of 1,000 mm. (*vide* p. 40), but this small difference is negligible, and we are accustomed to measure errors of refraction by the strength of the lens which is required when it is placed in the ordinary position of a spectacle lens (Fig. 35).

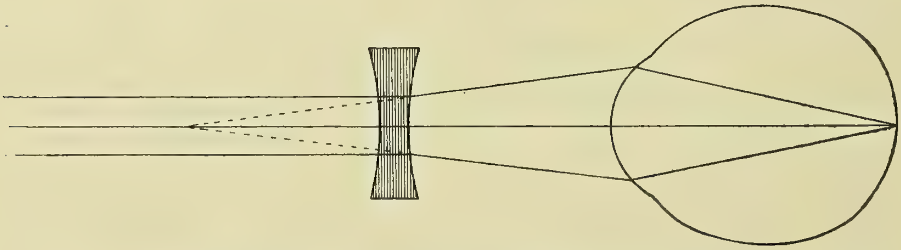

FIG. 36.—Myopic eye. Parallel incident rays brought to a focus on the retina by means of a suitable concave lens.

Similarly in myopia, if we give the rays the requisite amount of divergence before they enter the eye they will be brought to a focus upon the retina. We do this by placing a concave lens in front of the eye (Fig. 36). Here we should want a — 1 D lens in contact with the cornea to correct a myopia of 1 D, *i.e.*, an eye whose far point is 1 metre in front of the eye. Since the glass has to be worn about 20 mm. in front of the eye it

will have to be rather stronger, *i.e.*, it will have to be of a focal distance of 980 mm. instead of 1,000 mm.

There is an advantage in having the correcting glass in ametropia in the position of the anterior focus of the eye, because under these conditions the size of the retinal image is exactly the same as if the eye were emmetropic (Figs. 37, 39). The anterior focus is about 13 mm. in front of the eye, and this is so close that the lashes are apt to rub against the glasses, soiling them and causing discomfort. Hence spectacles are usually placed slightly farther away. We have already discovered one effect of this, viz., that the convex glass in hypermetropia has to be rather weaker, and that the concave glass in myopia has to be slightly stronger. It also has an effect upon the size of the retinal image, making it larger in hypermetropia and smaller in myopia (Figs. 38, 40). The increase in size in hypermetropia is advantageous, but the diminution in myopia is a disadvantage, especially in very high degrees. Consequently in the latter the glasses ought to be made to fit as closely to the eyes as possible, the eyelashes being cut short if necessary.

We have seen that in every case the far point and a point on the retina are conjugate foci. Hence an object situated at the far point of any eye will have a sharp image upon the retina (Fig. 34). This may be made clearer perhaps if we consider the myopic eye from another point of view. We have seen that the rays from a point on the retina meet in front of the eye at the far point. We may again use the principle of reversibility of rays. If there is a luminous point at the far point, the rays emitted from it which enter the eye will meet on the retina; in other words, the image of an object at the far point will be upon the retina.

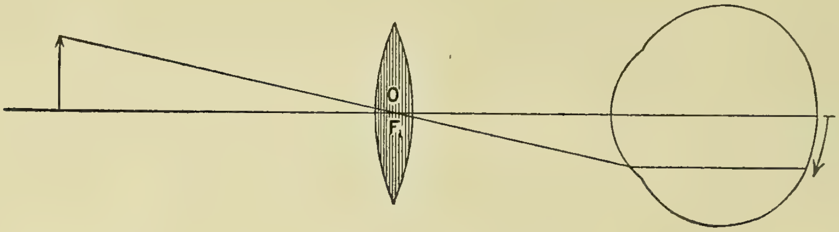

Fig. 37.

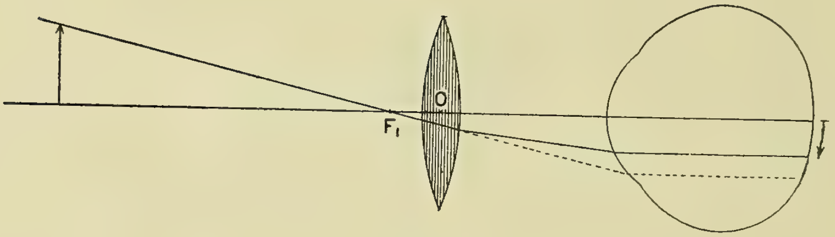

Fig. 38.

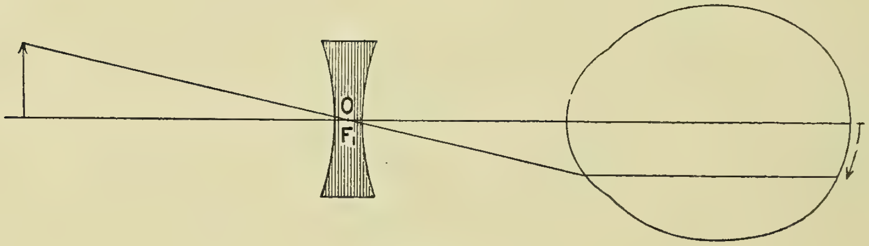

Fig. 39.

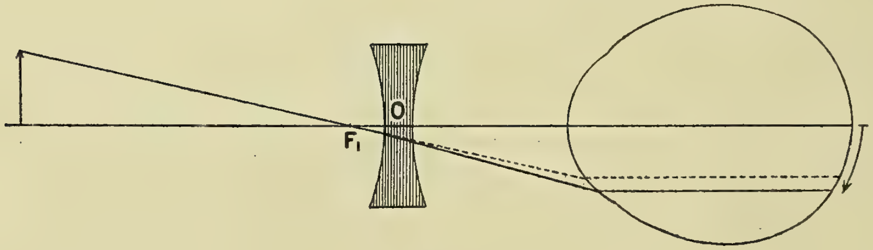

Fig. 40.

Figs. 37—40.—Effect of correcting lenses upon the size of the retinal image. In Figs. 37, 39, where the optical centre of the lens, O, coincides with the anterior focal point of the eye, F_1, the size of the retinal image is the same as in emmetropia. When the lens is closer to the eye than the anterior focal distance of the eye the size of the retinal image is diminished (convex lens, Fig. 38) or increased (concave lens, Fig. 40).

From these considerations we learn how it is that a patient with myopia cannot see clearly things which are a long distance away, whereas he can see things which are near. In common parlance, he is "short-sighted." He can see things at a distance better if he screws up his eyes. This is because he thus makes a narrow slit to look through, and this slit acts like the hole in the cardboard before a candle (*vide* p. 25). The term myopia originated in this peculiarity (μύειν, to shut; ὤψ, the eye or countenance).

The patient with hypermetropia, on the other hand, can see neither distant nor near objects clearly with his eyes at rest, since the far point is virtual, and it is impossible to place an object at its situation. We shall see later that he is better off than the myope by virtue of accommodation.

We have already seen that the emmetrope sees only distant objects clearly with his eyes at rest, since the rays from such distant objects are nearly parallel. For practical purposes objects more than 6 metres (20 feet) away from the eye form clear images upon the retina.

The condition of an eye, whether emmetropic, hypermetropic, or myopic, is called its refraction, or more accurately its static refraction, since the term applies to the eye at rest.

We have hitherto considered only such errors of refraction as are due to axial shortening or lengthening of the eye (*axial ametropia*). It is not difficult to understand that ametropia might be due to other causes. Thus, myopia might be due to the refractive power of the eye being too strong; in this case parallel rays would be brought to a focus in front of the retina even if this were in its normal position. Increase or decrease in the refractive power of the eye might be due to two causes. It might be due to alteration in the refractive indices of the media, or to alteration in the curvatures of the refractive surfaces: ametropia due to these causes is called *index* or *curvature ametropia* respectively. Both are much less common than axial ametropia. Index ametropia is very rare, though we shall have a physiological example of it later (*vide* p. 62).

Curvature ametropia has a special importance, not because it gives rise to simple hypermetropia or myopia, but because it is the cause of another very troublesome error of refraction, called *astigmatism*. In most eyes, even if they are ametropic, the areas of the refractive surfaces uncovered by the pupil and used in vision are very nearly spherical. Sometimes, however, they are not. In most of these cases it is the cornea which is at fault, and the error is generally of such a nature that this surface is flatter from side to side than it is from above downwards. Even in these cases the curvatures

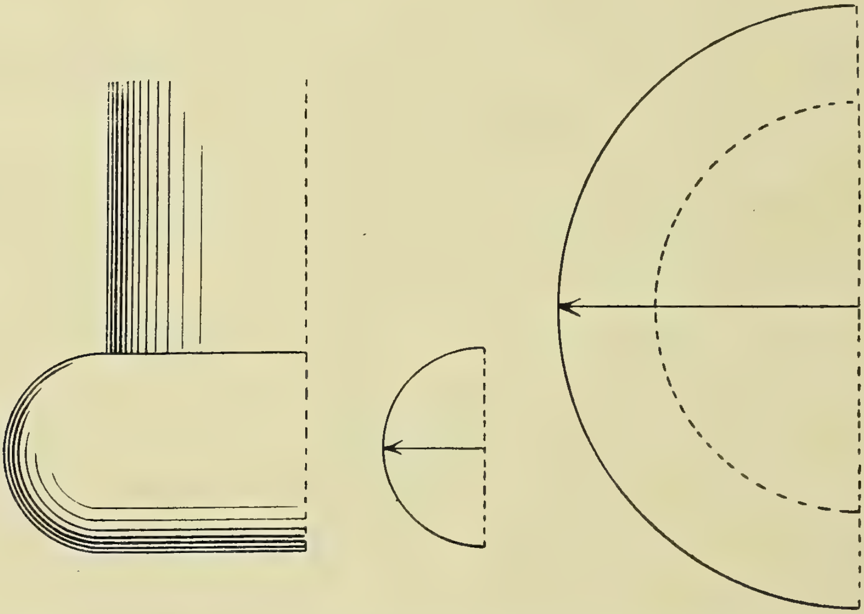

Fig. 41.—Base of an Ionic column, showing torus. The small section to the right shows the radius of curvature in the vertical direction, the large section that in the horizontal.

in the vertical and horizontal meridians are both spherical, but the radius of curvature of the horizontal meridian is longer than that of the vertical. Perhaps the pressure of the lids on the globe tends to squeeze it above and below. A familiar example of such a surface, which is said to have a *toric* curvature, is seen at the base of an ordinary Ionic column (Fig. 41). Here the centre of curvature of the horizontal section is the same as that of the column, whilst the centre of curvature of the vertical section is in a line with the surface of the upper part of the column. It is obvious that any other section of this surface than the vertical or horizontal will not be spherical but elliptical.

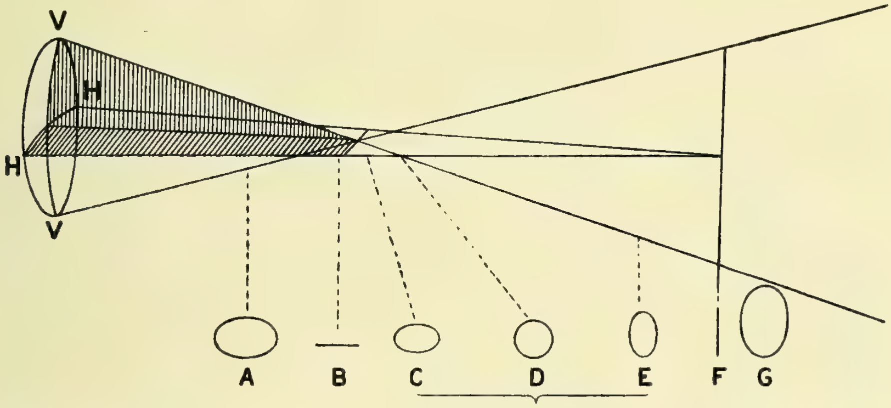

FIG. 42.—Sturm's conoid. V V, vertical meridian of refracting surface, more curved than H H, the horizontal meridian. A, B, C, D, E, F, G, sections of conoid. From B to F is the focal interval of Sturm. D shows the circle of least diffusion.

What will be the effect of such a toric cornea upon the refraction of the eye? Clearly the more curved meridian will have more refractive or convergent power than the less curved: hence if parallel rays fall upon the surface the vertical rays will come to a focus sooner than the horizontal. The rays after refraction will be perfectly symmetrical when referred to the vertical and horizontal planes. They will have two foci. The whole bundle of rays is called Sturm's conoid, and the distance between the two foci is called the focal interval of Sturm. It is difficult to represent this conoid on a plane surface (Fig. 42), but we can see what sections of the bundle or pencil of rays would look like at different distances from the refractive surface (Fig. 42, A—G).

At A the section will be a horizontal oval or oblate ellipse, because the vertical rays are converging more rapidly than the horizontal. At B the vertical rays have come to a focus, whilst the horizontal are still converging: the section will be a horizontal straight line. At C, D, and E the vertical rays are diverging and the horizontal are still converging. At one place in this focal interval there will be a spot (D) where the vertical rays have diverged from the axis exactly as much as the horizontal rays have converged towards it. Here the section is a circle, which is called the *circle of least diffusion.* At F the horizontal rays come to focus whilst the vertical are diverging: the section will be a vertical straight line. Beyond this point, as at G, both sets of rays are diverging and the section will always be a vertical oval or prolate ellipse.

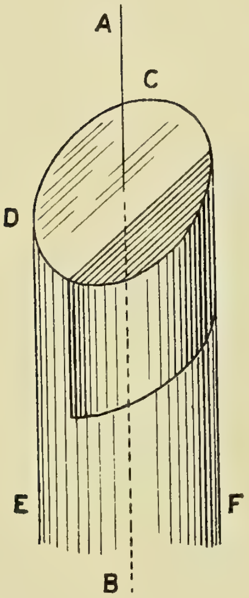

FIG. 43.

What will happen if the retina is situated at either of these points of section? In the first place it is obvious that the retinal image will always be blurred, and it is because the rays never come to a focus in a single point that the condition is called astigmatism (ἄ, privative, στίγμα, a point). If the retina cuts the conoid at A, where none of the rays have come to a focus, every meridian will be in the same condition, though in

different degree, as in the axial hypermetropic eye: this condition is therefore called *compound hypermetropic astigmatism.* If the retina is at B the vertical meridian will be in the condition of an emmetropic eye, whilst the horizontal will still be in the condition of a hypermetropic one: this condition is called *simple hypermetropic astigmatism.* At C, D, and E the vertical meridian will be in the condition of a myopic, and the horizontal still in that of a hypermetropic eye: this is called *mixed astigmatism.* At F the vertical meridian is still myopic, whilst the horizontal is in the same condition as in an emmetropic eye: this is *simple myopic astigmatism.* Beyond F, as at G, both meridians are in the condition of an axial myope, the rays having crossed in the vitreous: this is *compound myopic astigmatism.* All these positions of the retina are met with in actual practice, though ~~probably~~ there is often a combination of axial and curvature defects.

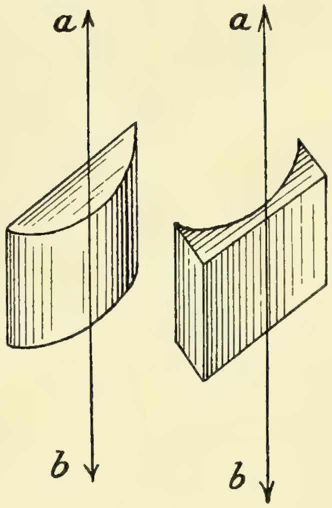

Fig. 44.

It will be readily seen that such a condition cannot be corrected by means of any spherical lens. We must obtain some means of affecting one set of rays more than the other. This means is found in cylindrical lenses.

Suppose CDEF is a cylinder of glass (Fig. 43): AB is called the axis of the cylinder. If a slice is cut off the cylinder by a plane parallel to the axis, it would form a cyclindrical lens. Fig. 44 gives representations of a convex and a concave cylinder. The direction *ab* is called the axis of the cylinder, since it is parallel to the axis of the original cylinder from which the slice may be supposed to have been taken. It is important here to warn the student not to confuse the axis of a spherical and the axis of a cylindrical lens, as they are totally different things. The axis of a cylinder has just been described: the axis of a spherical lens is the line joining the centres of curvature of the two surfaces.

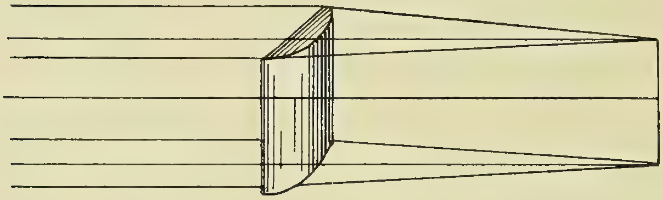

FIG. 45.—Refraction of parallel rays through a plano-convex cylinder.

How will a cylindrical lens affect parallel rays falling upon its surface? In the direction of its axis it is simply a plane lamina with parallel sides, so that it will have no effect upon the rays. In the direction at right angles to its axis it is spherical on one side and plane on the other: it will therefore act exactly like a plano-convex or a plano-concave lens, *i.e.*, it will make the rays either converge or diverge. If a convex cylinder is held between a point of light and a screen, a position can be found for the screen such that a sharp bright line is thrown upon it (Fig. 46): this is the focal line of the cylinder.

It is to be noted that the line is in the direction of the axis of the cylinder. If another convex cylinder of the same strength were held with its axis at right angles to the first, it would obviously form a focal line perpendicular to the first focal line. If the two cylinders are put in contact with their axes at right angles, all the rays after refraction must pass through both lines. The only place where they can

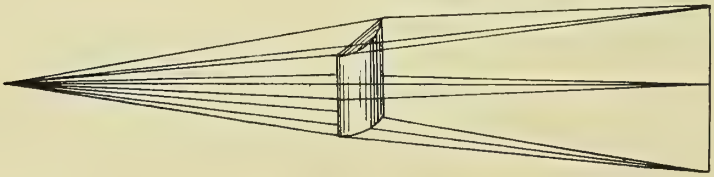

FIG. 46.—Refraction of divergent rays from a point of light through a plano-convex cylinder.

go through both lines is where the lines intersect. Hence we see that two cylindrical lenses of equal strength, placed in contact with their axes at right angles, act exactly like a convex spherical lens of the same strength as either of the cylinders.

When the cornea has its directions of greatest and least curvature at right angles to one another, the condition is called *regular astigmatism.* In the commonest form, as we have said, the vertical meridian is the more curved, the horizontal the less: this condition is generally called regular astigmatism "according to the rule." Sometimes the reverse is found: this is said to be "against the rule." Not infrequently the axes are oblique. Often after ulceration, &c., the surface of the cornea is irregular. This causes the rays of light to be refracted irregularly, so that there is no symmetry at all about them and different groups form foci in various positions. This is called *irregular astigmatism:* it cannot be corrected, and can only occasionally be improved by glasses.

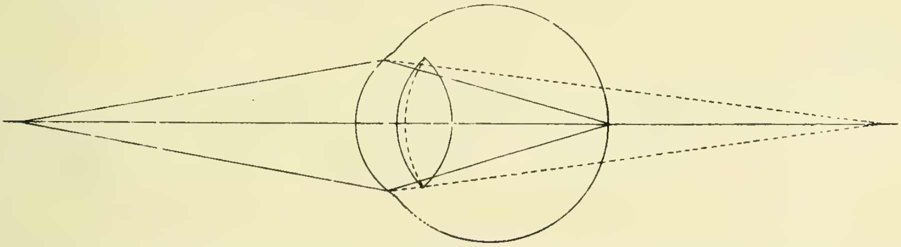

FIG. 47.—Effect of accommodation. The dotted lines show the curvature of the anterior surface of the lens and the course of rays with the eye at rest (static refraction). The solid lines show the curvature of the anterior surface of the lens and the course of rays with active accommodation (dynamic refraction).

Accommodation.—We have to consider now how it is that a person with normal sight can not only see distant objects, but also near ones. If an object is situated near the eye, *e.g.*, at ordinary reading distance—about 22 cm. or 9 inches—the divergence of the rays which it emits cannot be neglected. Since the converging power of the refractive media of the emmetropic eye is only strong enough to make parallel rays come to a focus on the retina, it is obvious that divergent rays falling upon the cornea will not nearly have come to a focus (Fig. 47). They will indeed be made convergent, but only to such a degree that they would meet somewhere behind the retina. Now if we can make the converging power of the eye stronger, a point may be reached when it is just strong enough to bring them to a focus on the retina. This is what is done by accommodation, and the manner in which the converging power of the eye is increased is by making the crystalline lens stronger.

We have seen that the refractive power of a convex lens depends upon its refractive index and upon the curvature of its surfaces. In accommodation, it is the latter which undergoes change. The curvature of the surfaces of the lens at rest in the eye is approximately spherical, and the radius of curvature of the anterior surface is 10 mm., whilst that of the posterior surface is 6 mm. In accommodation, the curvature of the posterior surface remains almost the same, but the anterior surface changes so that in strong accommodation its radius of curvature becomes 6 mm. The eye under these conditions, which are called its dynamic refraction, has a much increased converging effect upon the incident rays.

The mechanism by which this change in the curvature of the lens is brought about is as follows (Fig. 48). The lens substance is plastic, so that it tends to conform accurately to the shape of its capsule. As has been described (p. 12), the capsule is anchored to the ciliary body by the suspensory ligament. In the condition of rest, the fibres of the suspensory ligament are stretched. In the ciliary body is the ciliary muscle, which takes its origin from its anterior attachment to the sclerotic at

the angle of the anterior chamber. When the muscle contracts, it pulls the posterior part of the ciliary body and the anterior part of the choroid forwards slightly. The effect upon the suspensory ligament is to slacken it, and with it the lens capsule. The posterior surface of the lens is fixed by the support of the jelly-like vitreous, so that the slackening of the capsule makes itself most felt in the anterior part, which becomes bowed forwards.

The generally accepted theory here described is that of von Helmholtz. According to Tscherning the ciliary muscle tightens the suspensory ligament, so that the peripheral parts of the anterior surface of the lens are flattened and the central or pupillary area is increased in curvature.

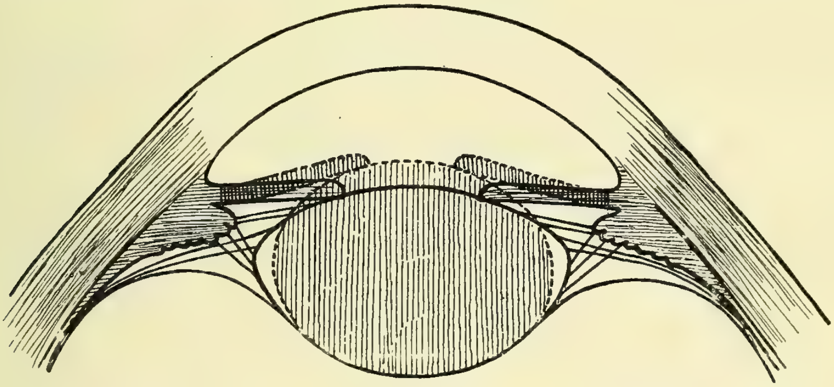

FIG. 48.—Diagram of Helmholtz' theory of accommodation.

Our control over the ciliary muscle, though involuntary, is very delicate, so that all distances up to quite close to the eye can be accurately focussed. The nearest point at which small objects can be clearly distinguished is called the *near point*, or *punctum proximum*. It is most accurately determined by gradually bringing a fine thread closer to the eye until it is found impossible to see it perfectly clearly. In practice it is sufficient to use very fine print and to determine the point at which it first becomes impossible to read it. The distance can be measured by a centimetre or inch tape held close beside the eye. For ordinary clinical purposes it is usually sufficient to judge the distance. At this point accommodation is exerted to its maximum, the lens capsule is as slack as it is possible to make it, and an object could only be seen clearly at a nearer point by placing a convex lens in front of the eye.

It has been shown that the far point of the eye varies according to its static refraction, *i.e.*, according to whether it is emmetropic, hypermetropic, or myopic. The near point also varies with the static refraction, but it also varies with the age of the patient, the reason being that the lens becomes less plastic as age advances. We have stated that the lens is a mass of epithelium of which the central part is the oldest (*vide* p. 12). As the lens gets older the central cells become tougher and more compressed, thus forming a relatively hard nucleus. The nucleus is less plastic than the younger cortex, and as age advances more and more of the fibres become converted into nucleus. Consequently the lens tends less and less to respond to changes in tension of the capsule. Thus, a child of ten, the earliest age at which it is possible to obtain satisfactory measurements, is able to see a small object clearly when it is only 7 cm., or less than 3 inches, from the eye. A person of thirty years of age cannot see clearly at less than 14 cm., or about 5½ inches from the eye.

Now, we have pointed out that the refractive power of a lens in dioptres is the reciprocal of its focal distance measured in metres (*vide* p. 36). The same method is applied to measure the static and dynamic refractive powers of the eye. Thus, the static refractive power of a myopic eye whose far point is 1 metre in front of the eye is said to be 1 dioptre; this is usually expressed by saying that the eye has 1 D of myopia. Similarly, if a hypermetropic eye has its far point half a metre behind the eye it is said to have 2 D of hypermetropia. By this method the emmetropic eye, which has its far point at

infinity, has no refractive power when it is at rest, since $\frac{1}{\infty} = 0$.

Applying the same method to the dynamic refractive power, the child of ten, whose near point is 7 cm. from his eye, has a refractive power of $\frac{100}{7} = 14$ D, and a man of thirty whose near point is 14 cm. from his eye has a refractive power of $\frac{100}{14} = 7$ D.

By this means we can obtain a general rule for indicating the amount or *amplitude of accommodation*, not only of emmetropic but also of hypermetropic or myopic eyes. This is given by the formula $A = P - R$, which states that the amplitude of accommodation is equal to the refractive power of the eye when fully accommodated (*i.e.*, the reciprocal of the distance of the near point in metres) less the refractive power of the eye at rest (*i.e.*, the reciprocal of the distance of the far point in metres).

A few examples will make this clearer. Thus, the emmetropic child of ten has an amplitude of accommodation of $\frac{100}{7} - \frac{1}{\infty} = 14 - 0 = 14$ D. What is the amplitude of accommodation of an emmetrope whose near point is 12·5 cm. from his eye? Here $A = \frac{1000}{125} - \frac{1}{\infty} = 8$ D. From statistics which have been collected we can deduce that this man was about twenty-six years old (*vide* p. 64). Now let us take a case of myopia, *e.g.*, a myope of 2 D whose near point is 8 cm. in front of his eye. His amplitude of accommodation will be $A = \frac{100}{8} - 2 = 10{\cdot}5$ D. What is the amplitude of accommodation of a hypermetrope of 3 D whose near point is 12·5 cm. from his eye? Here the far point is behind the eye and distances measured in this direction must have the opposite sign to those measured in front of the eye. Hence $A = \frac{1000}{125} - (-3) = 8 + 3 = 11$ D.

The numbers given by these calculations for the amplitude of accommodation give the strength of the convex lens which would have to be placed in contact with the cornea in order that the near point might be brought to the required distance without using the accommodation. Several interesting facts come to light from the calculations. Thus a hypermetrope of 3 D has to exert 11 D of accommodation in order that he may see clearly at 12·5 cm., whilst an emmetrope has to exert only 8 D of accommodation to bring about the same result. We see, then, that the hypermetrope has to exert an amount of accommodation equivalent to the amount of his hypermetropia in order to focus parallel rays upon his retina, *i.e.*, he has to use this amount of accommodation in order to see distance objects clearly. Again, in the case of the myope of 2 D, his far point is half a metre, or 50 cm., from his eye; he can see clearly at that distance without accommodating, but he has to exert 10·5 D of accommodation in order that he may see clearly at 8 cm. from his eye. This patient, then, has to exert nearly as much accommodation to alter his points of clear vision from 50 cm., to 8 cm., *i.e.*, through 42 cm., that a hypermetrope of 3 D has to employ in order to move his point of distinct vision from infinity up to 12·5 cm.

The effect of age upon the static and dynamic refraction is given in Fig. 50, which is the result of a large number of statistics and gives the average results. From this table we see that even the far point alters in advanced age. After about fifty the eye tends to become hypermetropic, so that at eighty it has about 2·5 D of

[We see therefore that the range of accommodation, i.e. the distance between the far point & the near point, is not always the same for a given amplitude.

hypermetropia. This has nothing to do with accommodation, and hence nothing to do with loss of plasticity in the lens. It is, however, due to changes going on in the lens, viz., an alteration in its refractive index so that it has a weaker converging power.

The refractive indices of the successive layers of the lens increase from the periphery towards the nucleus. The effect is twofold: it tends to correct aberration by increasing the convergence of the central rays, and the total refractive index of the whole lens is increased, being greater than the refractive index of the nucleus. For it may be looked upon as a central bi-convex lens encapsuled in two menisci (Fig. 49). The menisci act as concave lenses because the curvature of the nucleus is greater than that of the periphery of the lens. Hence they tend to counteract the effect of the central lens, but not so much as if their refractive index was the same. In old age the index of the peripheral layers increases, so that the total refractive index of the lens becomes less, and the eye becomes hypermetropic.

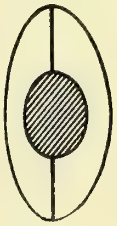

FIG. 49.

If we turn our attention to the curve of the near point we see that the amplitude of accommodation gradually diminishes throughout life. Now, we are accustomed to hold books for reading or work for sewing, &c., at about 10 inches, or 22 cm., from the eyes. In order to be able to see clearly at 25 cm. from the eye we have to exert $\frac{100}{25} = 4$ D of accommodation. If we look at the table we shall see that an emmetrope has only 4 D of accommodation left at about forty-one years of age. He will still be able to see clearly at 25 cm., but not closer. If he is about forty-six he will only have 3 D of accommodation left. He will not now be able to see clearly at 25 cm., but he will have to hold his book farther off, viz., at $\frac{100}{3} = 33$ cm. If he is still older he will have to hold the book yet farther off, and he will probably have to use very large print or he will not see clearly at all. This is the condition which is called *presbyopia* (πρέσβυς, old).

It will be seen that a patient never requires more than + 4 D to correct his presbyopia only, since that is the amount of accommodation required to place the far point of the resting emmetropic eye at reading distance. A convenient rule to remember is that a presbyope requires + 1 D for every five years after forty; *i.e.*, at forty-five, + 1 D; at fifty, + 2 D; at fifty-five, + 3 D; at sixty and later, + 4 D. The rule errs in giving rather too liberal a correction; a slightly smaller correction is often more comfortable.

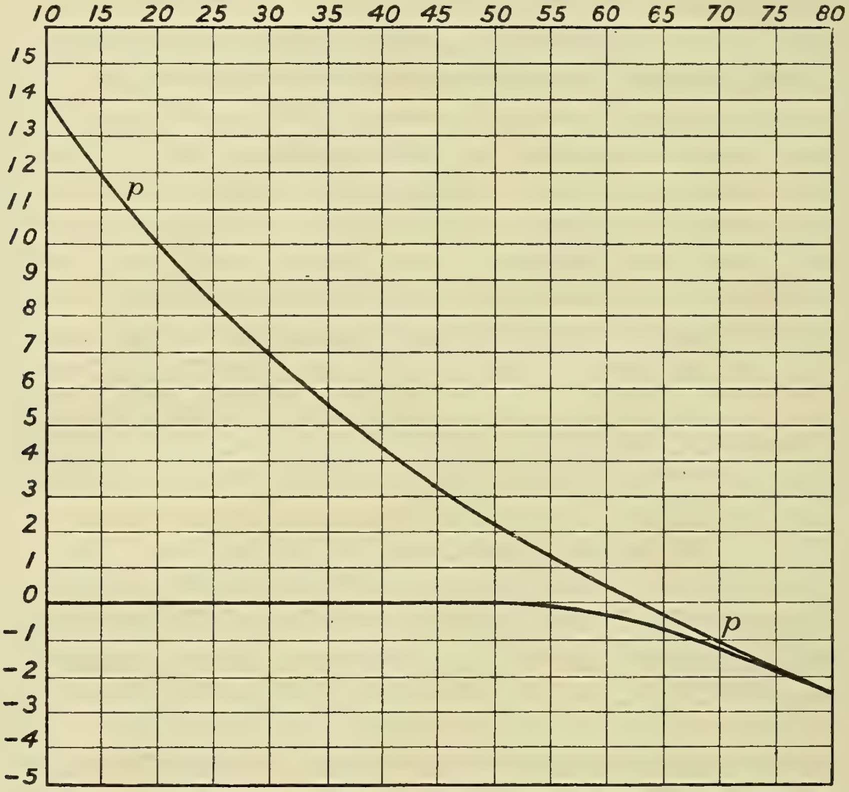

FIG. 50.—Chart of static and maximum dynamic refraction at various ages. (Donders.) Abscissæ, ages; ordinates, accommodation in dioptres.

It is a common error amongst students to think that presbyopia is a condition which commences at about forty-five years of age in emmetropes, and earlier in hyper-

③

Contraction of the pupil during accommodation is not for the purpose of diminishing aberration, since this is already diminished by the act of accommodation. It has the effect of compensating for the relative increase of light entering the eye from near objects, which is greater than is necessary [illegible] the results.

metropes. Of course this is not so: the condition which has been increasing throughout life first becomes troublesome when the near point of the eye has receded so far that it is beyond comfortable reading distance.

There are two other phenomena which occur with accommodation, one affecting the iris, the other the direction of the eyes. In order that we may see a near object we must look at it; hence in order that we may see it at the same time with both eyes they must each turn inwards or converge. The amount of convergence, like the amount of accommodation, depends upon the distance of the object. It is therefore easy to understand that there is a ~~near~~ relationship between accommodation and convergence. We shall have more to say upon this subject when we consider the various forms of squint.

/close

When we accommodate for a near object the pupil becomes smaller, or contracts. Experiment has shown that this movement of the iris is associated with the accompanying act of convergence rather than with accommodation *per se*. ~~It is not easy to explain the object of contraction~~ of the pupil on ~~convergence~~; it is probably of the nature of an associated movement, or, as I have termed it, synkinesis (σύν, with, κίνησις, movement). ⅄

⅄ (3)

It is not uncommon for the refraction of the two eyes to be different: this condition is called *anisometropia* (ἄ, privative; ἴσος, equal; μέτρον, measure). It might be anticipated that this could be corrected to some degree or entirely by unequal accommodation in the two eyes. Thus, if one were emmetropic and the other hypermetropic both eyes would be able to distinguish distant objects clearly if the hypermetropic one alone accommodated the requisite amount to correct its hypermetropia. It has been conclusively proved, however, that this does not occur. When these cases are not corrected by the proper glasses clear vision is wholly uniocular.

Although astigmatism is chiefly due to faulty curvature of the cornea, in some cases there is also lenticular astigmatism. This is not generally due to unequal curvature of the surfaces, but to slight tilting of the lens, so that the incident rays fall upon it obliquely. If we look through a tilted glass lens at printed matter we shall see that the letters become distorted and elongated in one direction; this is a form of astigmatism. The astigmatism of the crystalline lens is generally of such a nature that it tends to counteract the corneal astigmatism, though sometimes it adds to the effect. As in anisometropia, it might be thought that astigmatism could be corrected by accommodation. If, for instance, the ciliary muscle acted only at the sides and not at all above or below, the anterior surface of the lens would become more curved in the horizontal than in the vertical meridian. This would counteract the effect of the ordinary form of corneal astigmatism. It has been proved, however, that this also does not occur. When the ciliary muscle acts, it acts equally all round the circle; and when one ciliary muscle acts, the one in the opposite eye acts simultaneously and equally under ordinary conditions.

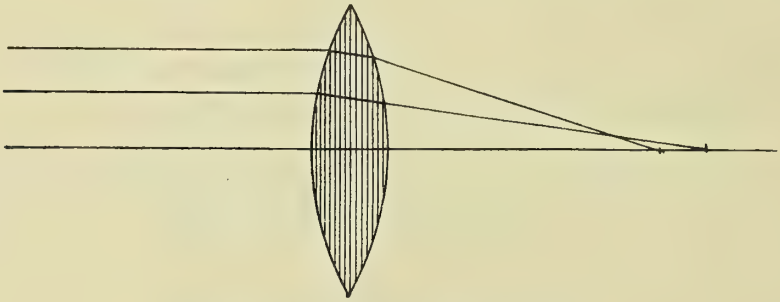

FIG. 51.—Spherical aberration.

THE PUPILS.

The iris acts like the diaphragm of any ordinary optical system, such as a photographic camera or a microscope.

In discussing the effects of spherical mirrors in reflecting, and of spherical surfaces in refracting the rays of light, we said that in each case they were all brought to a focus in a single point. This is really only an approximation, which is sufficiently accurate for rays close to the axis. In a convex spherical lens, for instance, parallel rays near the axis meet at the principal focus (*vide* p. 32). The rays farther away from the axis, however, are refracted too much, so that they cut the axis nearer the lens than the principal focus (Fig. 51). This causes a blurring of the edges of the image, which is said to be due to *spherical aberration.* The diaphragm cuts off these peripheral rays, and thus prevents the blurring. In the eye the surfaces are not even spherical near the periphery, and are often not so in the centre, so that much more aberration is liable to occur. The iris reduces the effects of the evil to a minimum.

There is also another form of aberration due to the imperfect refraction at spherical surfaces. White light is made up of all the colours of the spectrum. The component rays are refracted differently, the violet most, the red least. Hence there is a tendency for the white light to be split up into its components, in which case the image will have a coloured edge. This phenomenon is called *chromatic aberration.*

When light enters the eye and falls upon the retina the pupil contracts. We have already seen that the pupils also contract when the optic axes converge in accommodation. On the other hand they dilate if the skin of any part of the body is pinched or any sensory nerve is stimulated to the extent of causing pain. These responses to stimuli of various kinds are very rapid and delicate, and are easily observed. When they are altered by disease the changes which occur afford very valuable information as to the condition of the nerve tracts involved. The tracts are rather complicated, but it is essential that they should be understood.

Under normal conditions, with equal illumination—a point too frequently neglected—the pupils are equal on the two sides. It is very rare to meet with unequal pupils in a normal person; such cases do apparently occur, but every possible pathological cause must be eliminated before we admit that the condition is an idiosyncrasy.

On the other hand, the size of the pupils varies much in different people under the same conditions of illumination, &c. In old people it is smaller than in the young, sometimes to so great an extent that the pupils are almost "pin-point." They are often smaller in hypermetropes, and larger in myopes, than in emmetropes; they are said to be smaller in blue eyes than in brown. The causes of these differences are conjectural, and need not detain us. The two facts of prime importance have been mentioned, viz., that there are two reflexes, that to light and that to sensory stimulation, which act in opposite directions. The normal size of the pupil may be looked upon as essentially the resultant of these two forces.

The motor innervation of the pupil is as follows (Fig. 52). The sphincter pupillæ is innervated by the third cranial nerve. The pupil-constrictor fibres start in the anterior part of the third nucleus in the floor of the aqueduct of Sylvius. They pass out of the mid-brain and run in the main trunk of the third nerve as far as the orbit. Here the fibres pass into the branch which supplies the inferior oblique muscle, leaving it by the short root of the ciliary ganglion. From the ciliary ganglion they pass by the short ciliary nerves to the eye, piercing the sclerotic around the optic nerve, being here in company with the short ciliary arteries (*vide* p. 14). The nerve fibres pass forwards in the choroid and ciliary body to the iris.

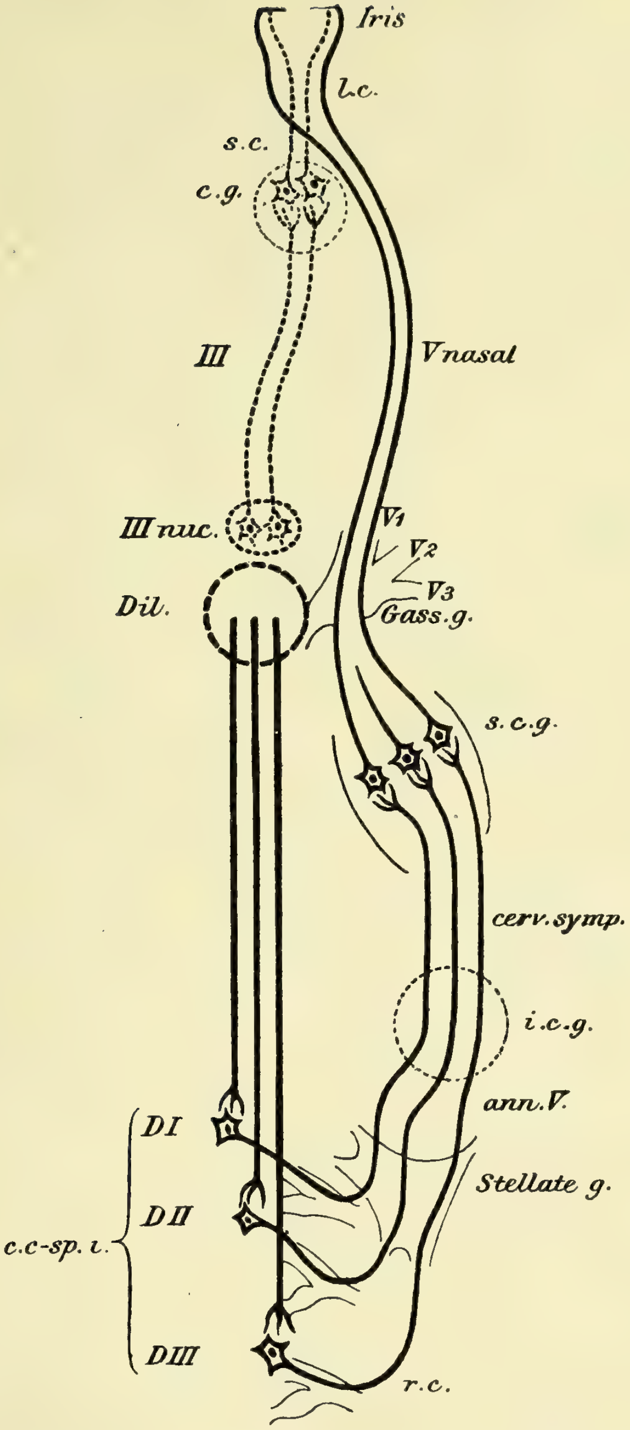

FIG. 52.—Diagram of the efferent pupillary paths. Dotted lines, pupillo-constrictor: *III nuc.*, nucleus of third nerve; *c.g.*, ciliary ganglion; *s.c.*, short ciliary nerves. Solid lines, pupillo-dilatator: *Dil.*, hypothetical dilatator centre in the medulla; *c.c-sp.i.*, Budge's centrum cilio-spinale inferius; *D I*, *D II*, *D III*, first, second, and third dorsal nerves (see text); *r.c.*, ramus communicans; *Stellate g.*, stellate ganglion; *ann. V.*, annulus of Vieussens; *i.c.g.*, inferior cervical ganglion; *cerv. symp.*, cervical sympathetic; *s.c.g.*, superior cervical ganglion; *Gass. g.*, Gasserian ganglion; *V1*, *V2*, *V3*, first, second, and third divisions of the fifth nerve; *V nasal*, nasal branch of the ophthalmic (first) division of the fifth nerve; *l.c.*, long ciliary nerves.

The dilatator pupillæ is supplied by the cervical sympathetic nerve. The dilatator tract probably commences in the mid-brain not far from the constrictor tract. It passes downwards through the medulla oblongata into the lateral columns of the cord. The fibres leave the cord by the ventral roots of the first three dorsal and probably the last two cervical nerves, enter the rami communicantes, and run to the first thoracic or stellate ganglion. From here they pass by the anterior limb of the annulus of Vieussens into the cervical sympathetic. In this nerve they run up the neck to the superior cervical ganglion, whence they pass with the carotid plexus into the skull. They run over the anterior part of the Gasserian ganglion and pass into the first or ophthalmic division of the fifth nerve, following the nasal branch, which they leave finally to enter the

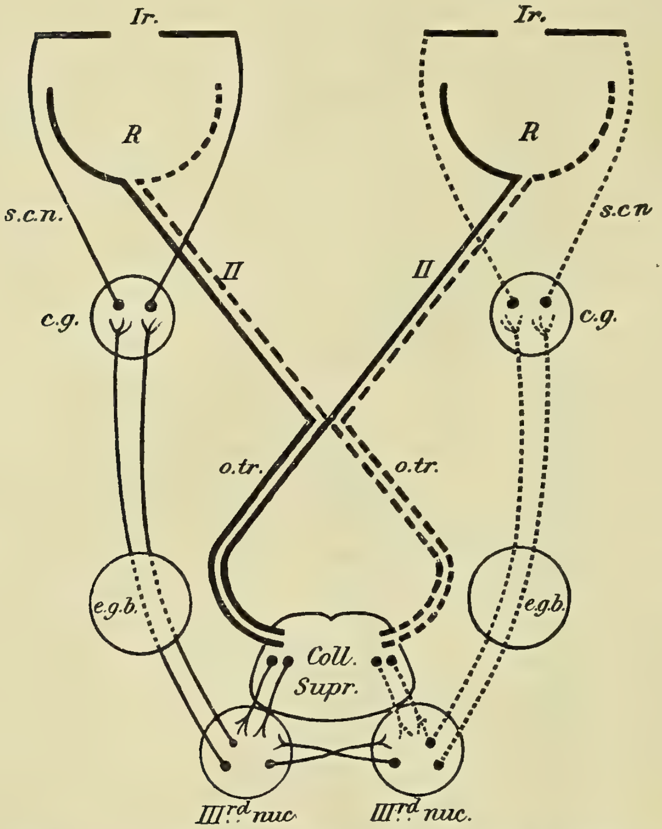

FIG. 53.—Diagram of the afferent and efferent pupillary paths for light stimuli. Afferent paths from left sides of retinæ, thick solid lines; afferent paths from right sides of retinæ, thick dotted lines; efferent paths of left eye, thin solid lines; efferent paths of right eye, thin dotted lines. *Ir.*, iris; *R*, retina; *II.*, optic nerve; *o.tr.*, optic tract; *Coll. Supr.*, colliculus superior or anterior corpus quadrigeminum; *IIIrd nuc.*, nucleus of third nerve; *e.g.b.*, external geniculate body; *c.g.*, ciliary ganglion; *s.c.n.*, short ciliary nerves.

long ciliary nerves, thus avoiding the ciliary ganglion. The long ciliary nerves enter the eye on each side of the optic nerve, accompanying the long ciliary arteries. Like them, they run forwards between the choroid and sclerotic, enter the ciliary body and thus reach the iris.

These complicated paths will be seen at a glance in the accompanying diagrams.

We have now to consider the nervous mechanism of the reflexes. The light reflex is carried out entirely through the constrictor centre, so we may put the dilatator tract aside for the moment. The afferent fibres are contained in the optic nerve, arising from all parts of the retina (Fig. 53). It is unknown whether they belong to the large or the small fibres of the optic nerve. It is certain that they undergo partial decussation in the chiasma, like the visual fibres, and that they enter the optic tracts. It is also certain that, unlike the visual fibres, they do not enter the lateral geniculate body, but leave the tract to pass by an unknown path to the third nucleus.

The constrictor centre possesses "tone," *i.e.*, it is perpetually sending out impulses which keep the pupil slightly contracted. If light falls upon the retina of one eye its pupil constricts—*the direct reaction to light;* but the pupil of the opposite eye also contracts simultaneously—*the consensual reaction to light.* This consensual reaction should always be tested since it gives useful information which cannot be obtained from the direct reaction. Thus, if there is a block on one optic nerve so that there is no direct reaction to light, but the consensual reaction from light thrown upon the other eye is unimpaired, we know that the block, whatever it may be, does not affect the efferent constrictor tract, *i.e.*, the trunk of the third nerve, the branch to the inferior oblique, and the short ciliary nerves are intact. The consensual reaction is probably carried out by means of fibres which unite the two constrictor centres in the third nucleus.

That the afferent pupil-constrictor fibres undergo partial decussation in the optic chiasma is proved by Wernicke's *hemianopic pupil reaction.* This reaction is pathognomonic of disease of one optic tract. It will be seen from Fig. 53 that such a lesion will cut off the afferent impulses from corresponding halves of each retina, *i.e.*, from the temporal half of one and the nasal half of the other. If light is thrown upon these parts of the retinæ the pupils do not contract, but if it is thrown on the other halves of the retinæ the pupils respond.

The sensory reflex is more complicated than the light reflex, for both the dilatator and the constrictor centres play a part in its production under normal conditions. It has been shown that sensory stimulation causes first a a rapid dilatation of the pupil due to augmentation of the dilatator tone through the cervical sympathetic, and then a second dilatation, rapid in onset but slow in disappearance, due to inhibition of the constrictor tone. There are other reflexes and synkineses, *e.g.*, emotional, which need not detain us.

Minute examination of the pupil when the intensity of the light entering the eye is altered, shows that the pupil contracts and then oscillates rapidly, finally settling down into a condition of contraction which is slightly less than the summit of the first wave. In its sudden response, the pupil as it were oversteps the mark, oversteps it again in the opposite direction, and so on. Two different types of exaggeration of this oscillation are met with under abnormal conditions. One is the condition in which the oscillations are very large and easily seen, and which are to a large extent independent of the light falling upon the eye. This is called *hippus;* its origin is obscure, but it undoubtedly depends upon the rhythmic

activity of the nervous centres, and is not a peripheral phenomenon. More important is the lack of sustained contraction under the continued influence of light. Here the pupil contracts sluggishly when the intensity of the light is increased, but whilst the light is still kept constant it slowly dilates, often with superposed sluggish oscillations. This is a pathological phenomenon dependent upon diminished conductivity in the afferent path of the light reflex, *i.e.*, usually in the optic nerve (*see* Retrobulbar Neuritis).

Drugs are so frequently employed in ophthalmic practice for the purpose of dilating or constricting the pupils or paralysing the accommodation, that it is important to know exactly how they act. Pupil-dilating drugs are called mydriatics; pupil-constricting, miotics; drugs which paralyse the ciliary muscle, cycloplegics. All drugs which dilate the pupil also paralyse the accommodation in greater or less degree; many attempts have been made to discover a drug which will effect the former purpose without the latter, but without success. Similarly, all miotics stimulate the ciliary muscle to contract, so that the eye assumes a condition of partial or complete accommodation.

The vexed question whether these drugs act upon the respective muscle fibres or upon the nerve endings contained in them need not be discussed here. The strongest mydriatic which we possess is *atropin;* it paralyses the sphincter iridis and ciliary muscle completely, and is said also to stimulate the dilatator iridis. It has so potent an action that it abolishes the tone of the ciliary muscle. Thus, an emmetropic eye placed fully under the influence of atropin becomes hypermetropic to the extent of about 1 D; this must be taken into account in correcting errors of refraction. Atropin solution (*e.g.*, 1 per cent.) instilled into the conjunctival sac is absorbed through the cornea into the anterior chamber, where it acts locally upon the intrinsic muscles. It takes a considerable time to cause complete paralysis, hence it is usual to order it for use at home three times a day for at least three days. The effects do not pass off for about ten days. One drop of 0·5 per cent. atropin sulphate solution causes wide dilatation of the pupil in thirty to forty minutes, and complete paralysis of accommodation in about two hours; the effects do not pass off entirely till from three to seven days. Duboisin, hyoscin, and daturin act similarly to atropin.

Homatropin acts more quickly than atropin, and the effects pass off more quickly. Its full effect is obtained by an oily solution (in Ol. Ricini, 1 per cent.) in three-quarters of an hour, especially if combined with cocain (2 per cent.), which acts chiefly by increasing the permeability of the cornea. The effects pass off completely in forty-eight hours, or much more quickly if a drop of eserin (1 per cent.) is instilled. The mixture of homatropin and cocain, which is commonly employed for estimating refraction, does not paralyse the intrinsic muscles so fully as atropin, the tone of the ciliary muscle not being abolished so thoroughly. Homatropin ~~alone~~ probably acts upon the iris through the sphincter only.

Cocain, besides its anæsthetic effect through the endings of the fifth nerve in the cornea, iris, &c., also stimulates the sympathetic nerve endings in the dilatator iridis. It does not paralyse the sphincter, so that the dilatation of the pupil is only moderate, and the pupil continues to react to light even after prolonged application. Cocain is a useful drug in confirming the diagnosis of paralysis of the sympathetic nerve: if this nerve is paralysed cocain fails to dilate the pupil. The effect is not due to degeneration of the nerve endings, as I have found that cocain fails to act very soon after section of the sympathetic in the neck in animals.

Eserin or physostigmin, the most powerful miotic we possess, acts by stimulating the third nerve endings in the sphincter and in the ciliary muscle. It is therefore an antagonist of atropin, but it is unable to overcome the dilatation produced by atropin. On the other hand, eserin readily overcomes the dilatation produced by homatropin and cocain. These facts are of very great importance and must be carefully borne in mind. ~~Comparably~~ with cocain eserin fails to produce constriction of the pupil after section of the third nerve.

[illegible]

Eserin, unlike the common mydriatics, causes some smarting and injection of the ciliary vessels when instilled into the conjunctival sac. What is more unpleasant is the "dragging" sensation in the eye which patients complain of when it is acting. It may be so irritating as to cause vomiting, but this only occurs in very sensitive persons or when the drug is pushed. Owing to these symptoms it should not be instilled more frequently nor in stronger doses than requisite to ensure the desired result. A 0·5 per cent. solution or one considerably weaker is often adequate.

Eserin begins to contract the pupil and cause spasm of accommodation in about five minutes; its maximum effect is reached in twenty to forty-five minutes. The effect on accommodation lasts only an hour or two, that on the pupil two to three days.

Pilocarpin acts similarly to eserin, but is less potent.

In irritative miosis, due to stimulation of the third nerve, light, accommodation, and eserin will cause greater constriction, atropin dilatation. In paralytic miosis, due to paralysis of the sympathetic, light, accommodation, and eserin will cause constriction, atropin little or no dilatation.

In spastic mydriasis light, accommodation and eserin will cause constriction. In paralytic mydriasis there is no reaction to light or accommodation, and eserin acts very feebly.

VISUAL PERCEPTIONS.

When light falls upon the retina it acts as a stimulus to a sensory nerve ending. As contact of the skin with a foreign substance causes the sensation of touch, so stimulation of the retina causes visual perceptions. The changes which go on as the result of a suitable stimulus in an ordinary tactile end organ, the physiological impulses in the afferent sensory nerves, and the psychological interpretation of these impulses in the brain which we call tactile sensation, are all relatively simple. In the visual nervous mechanism they are much more complex and highly differentiated.

We may first very briefly consider the changes which occur in the end organ itself. Light falling upon the retina causes at least four effects. (1) The pigment in the hexagonal cells of the retinal epithelium migrates from the bodies of the cells into the processes which lie between the rods and cones. (2) The cones become shorter. Both these effects are slow; both give more response to the violet end of the spectrum than to the red end; both are consensual as well as direct—light on one retina causes the effect on both, though the other be kept in darkness. (3) The visual purple, a substance which is found only in the rods, is bleached, so that a sort of photograph or optogram of the luminous object is formed. (4) Changes of electrical potential are set up in the retina.

We are more concerned, however, with the sensations which result from stimulation of the retina with light. These are of three kinds, which are called the Light Sense, the Colour Sense, and the Sense of Form. Each of these may become disordered, so we must examine what they really mean.

The light minimum for the fovea is considerably higher than for paracentral & peripheral parts of the retina, & retinal adaptation affects the macula relatively little.

The *Light Sense* is the faculty ~~of the retina~~ which permits us to perceive light, not only as such, but in its gradations of intensity. By utilising shadows cast by the retinal blood vessels upon the rods and cones it can be proved that the neuro-epithelium is the actual sentient layer of the retina. It is in this layer that the clear image of objects in the outer world are focused. The rays stimulate the rods and cones and give us the sensation of light.

If the light which is falling upon the retina is gradually reduced in intensity there comes a point when it is no longer perceived: this is called the *light minimum.* It varies very greatly according to the amount of light which has been falling upon the retina before the observation is made. We are all aware that if we go from bright sunshine into a dimly lit room we cannot perceive the objects in the room until some time has elapsed: the eyes have to become "adapted" to the amount of illumination. Hence observations on the light minimum are only comparable one with the other when the eye is in the condition of dark adaptation. Since this involves keeping light from the eye for at least twenty to thirty minutes the investigation is tedious, and perhaps this is the chief reason why it is much neglected clinically.

Having ascertained the light minimum, if the light is gradually increased in intensity there are points at which we can clearly distinguish a difference in the amount of illumination. We can do this best if we have two illuminated areas of equal size to compare, as is done in special instruments for the purpose, called photometers. We can then find out how much brighter one area must be in order that we may distinguish a difference in illumination. This is called the *light difference.* It is found to vary with the amount of illumination—the greater the amount of illumination the greater will have to be the difference in order that we may be conscious of any difference at all. Indeed, light difference follows a well-known law which is valid for all sensory impressions. ([illegible])

Neither of these functions of the light sense ~~are~~ is much used in ophthalmology. There is no doubt that the light minimum is increased in diseases which impair the percipient elements, viz., the rods and cones (see Retinitis pigmentosa). It is said that disease of the conducting elements, the nerve fibres, causes increase in the light difference.

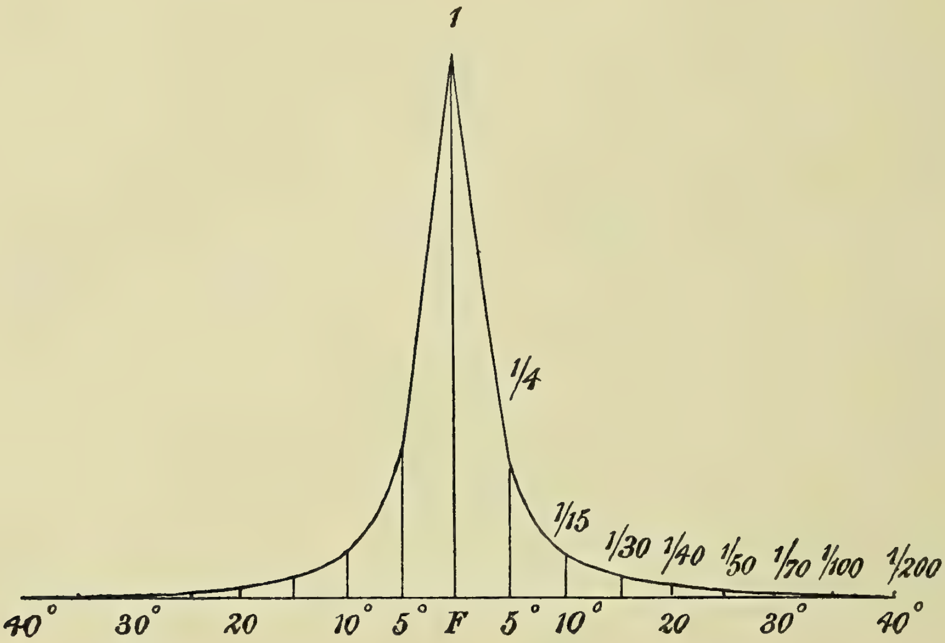

Fig. 54.—Acuity of form sense in different parts of the retina. (Dor.) *F*, fovea centralis. Abscissæ, degrees towards the periphery of the retina ; ordinates, relative acuity, that at the fovea being unity.

The rods appear to be much more sensitive to low illumination than the cones, so that in the dusk we see with our rods. Nocturnal animals, like the bat, have few or no cones.

The *Form Sense*, which is next in importance, is the faculty ~~of the retina~~ which enables us to perceive the shape of objects in the outer world. Here the cones

L (Scotopic vision)

(4) [(Small print).

The form sense is not a purely retinal function, but in the perception of composite forms, such as letters, is largely psychological. The purely physiological elements which enter into the complex form sense are (1) the light sense; (2) the sense of position; + (3) the sense of discrimination. The sense of position depends upon the light sense + upon the [illegible] of contrast between the object + its background. A physiological process, called spatial induction, causes a lowering of sensibility of the area surrounding a stimulated area, so that the contrast between the two areas is increased. The sense of position is measured by the minimum visibile. The sense of discrimination, the power to distinguish two visible objects as separate, is measured by the minimum separabile. Form sense is measured by the minimum legibile or cognoscibile.

play the ~~greatest~~ part, and where they are most massed together and most highly differentiated, viz., at the macula, there the form sense is most acute. It falls off very rapidly towards the periphery, as is shown in Fig. 54, and it is noticeable that the curve agrees fairly well with the diminution in the number of cones. We are accustomed to speak of acuity in distinguishing the shapes of objects as *acuity of vision,* and we mean by that the greatest acuity which it is possible to obtain. The acuity of vision, therefore, applies to central vision, or the vision of objects whose images are formed at the fovea and its immediate neighbourhood, the macula lutea. (4)

In determining the acuity of vision, we utilise the visual angle (*vide* p. 44). We naturally choose as our basis the *minimum visual angle, i.e.,* the angle which two luminous points must subtend at the nodal point of the eye in order that they may be perceived as separate and distinct. Now, in order that we may get separate impressions from two points close together on the retina it is necessary that two cones shall be stimulated, and that there shall be a cone between these two which is not stimulated. If we know the diameter of a cone we can calculate the minimum angle which must be subtended at the nodal point in order that these requirements may be fulfilled. This angle, as we have already seen, is equal to the angle subtended on the other side of the nodal point by the two luminous points. As a matter of fact these calculations agree fairly well with the results of observations. It might be thought that the observation was a very easy one, but there are several complications. It is found that there is a certain amount of spread of the stimulus from one cone to surrounding ones, due chiefly to natural irregular astigmatism of the refractive media, especially the lens. This causes bright objects on a dark background to appear a little larger than they really are:

the phenomenon is called irradiation. It is not altogether a disadvantage, for it helps us very much in seeing actual points of intense light, like the stars, millions of miles away. In clinical work it would be a disadvantage to have an unduly high standard of visual acuity, because nearly everybody would be abnormal according to the standard. It is found that a minimum visual angle of 1 minute (1′) or one-sixtieth of a degree gives a very good average, and it is upon this basis that test types are constructed (*vide* p. 156).

The *Colour Sense* is that faculty ~~of the retina~~ whereby we are enabled to distinguish different colours and different colour tones. The exact investigation of the colour sense is one of great complexity, for the different colours of the spectrum differ in luminosity, so that this disturbing factor has to be added to those dependent upon the physiological condition of the retina, *e.g.*, its state of adaptation, and so on.

If three colours sufficiently far apart on the spectrum are chosen, all the other colours can be formed by their combination in suitable proportions, and white light can also be formed in the same manner. There are reasons for choosing red, green and blue for these "primary" colours. Now, we know that physiological impulses are in some sense a reflex or image of the physical stimuli which give rise to them, *e.g.*, sound waves cause physiological impulses, which are perceived as sound, and so on. If, therefore, we imagine three slightly different kinds of impulse set up by the stimulation of the retina by red, green and blue light respectively, their combinations in suitable proportions would enable us to perceive the whole gamut of the spectrum, including white light. This is the basis of the Young-Helmholtz theory of colour vision. According to Hering's theory, chemical changes in three different types of "visual substance" situated in the retina a though not in the same degree of saturation,

b Hence normal colour vision is called trichromatic.

cause the sensations of colour (including white and black). The three substances are white-black, red-green, and blue-yellow. If anabolic or building-up changes (Assimilation) are set up in these substances, the sensations of white, red and blue are caused respectively. If katabolic or breaking-down changes (Dissimilation) are set up, black, green and yellow result.

Perhaps no subject affords a better field for conjectures than the theory of colour vision. It is sufficient here for us to emphasise the importance of the three primary colours, upon which stress is laid by the Young-Helmholtz theory, and the intimate relations which exist between red and green, blue and yellow, and white and black, which ~~is~~ are the foundation of the Hering theory. It is necessary to realise so much because the colour sense is defective in a fairly large proportion of people. This congenital abnormality is called *colour blindness* (*q.v.*). In it the importance of the three primary colours and the intimate relation of the pairs of colours are forcibly brought out.

The three types of visual perception are not confined to the minute area of central or macular vision. All are present in greater or less degree in more peripheral parts of the retina. In disease the earliest and most delicate traces of failing function are often to be found in the peripheral parts, central vision remaining perfectly normal. Hence the great importance of knowing the normal limits of the light perceptive and the colour perceptive areas of the retina.

The *field of vision* is the projection of these percipient areas of the retina on the outer world. When we stand upon the sea shore and look at or "fix" a ship on the horizon it forms a retinal image at the fovea. We are accustomed, then, to consider that any object in the outer world which forms the image at the fovea is situated somewhere upon the *line of vision*, *i.e.*, the line passing through the fovea and the nodal point of the eye. The foveal image is "projected" outwards along this line. Whilst still fixing the ship we are conscious of seeing, less clearly, innumerable objects for miles around. From our knowledge of the refractive mechanism of the eye we know that these objects must form their retinal images upon peripheral parts of the retina. Regarded from the side of the eye the image upon any point of the peripheral part of the retina is "projected" outwards along the line joining the point with the nodal point. The field of vision, then, is the projection outwards of all the points upon the retina which can give rise to visual perceptions. We will postpone the consideration of its properties to a later stage (*vide* p. 165).

CHAPTER V.

THE NEUROLOGY OF VISION.

In the preceding chapter we have considered the process of vision up to the point at which the retinal receptive elements, the rods and cones, have become stimulated. As with other sensory nerves, stimulation

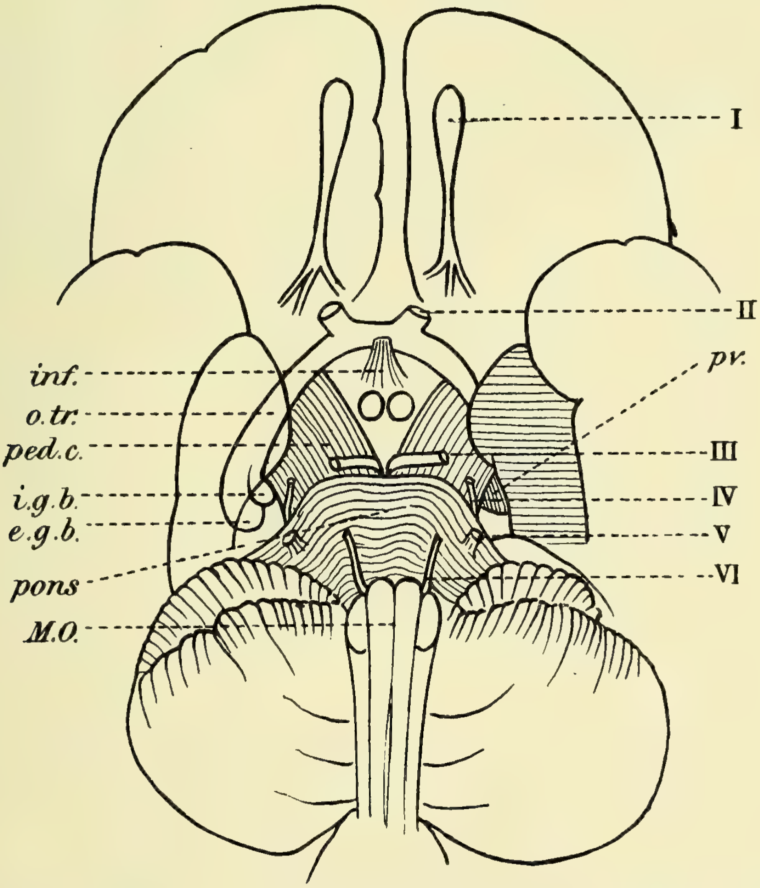

FIG. 55.—Diagram of the base of the brain, showing superficial origin of the I, II, III, IV, V, and VI cranial nerves : *inf.*, infundibulum ; *o.tr.*, optic tract ; *ped.c.*, cerebral peduncle ; *i.g.b.*, internal geniculate body ; *e.g.b.*, external geniculate body ; *pv.*, pulvinar of optic thalamus ; *M. O.*, medulla oblongata.

of the end organ causes the development of nervous impulses which travel up the afferent tracts of the central nervous system to the brain. The comparison of the afferent tracts of common sensation with those of vision throws so much light upon the latter that it is worthy of a moment's consideration.

The sensory impulse of common sensation, *e.g.*, in the leg, is carried by a nerve fibre along the sensory nerve and the dorsal spinal root to the cord : it travels up in the posterior columns of the cord to the nucleus gracilis or the nucleus cuneatus as the case may be (Fig. 56). The whole of this course is along the processes of a single cell or neuron, which has been called the neuron of the first order. The impulse is taken up in the nucleus gracilis or cuneatus by a second cell, and is carried along the nucleo-thalamic tract or mesial fillet to the opposite optic thalamus; other fibres, especially those derived from the nucleus cuneatus, pass to the superior colliculus or corpus quadrigeminum. The cells in the nuclei gracilis and cuneatus are the neurons of the second order. A third cell, the neuron of the third order, situated in the thalamus or colliculus, carries on the impulse to the cortex cerebri. Here the nervous impulse is transformed into a psychic impulse, a change which is not and probably never can be understood.

Let us compare with this the visual afferent tracts (Fig. 57). The end organ is the neural epithelium of rods and cones. The first true conducting nerve cell or neuron of the first order is the bipolar cell of the inner nuclear layer with its axon in the inner reticular layer. This microscopic cell corresponds morphologically with a dorsal root ganglion cell and its long processes stretching in some cases from the tip of the toe to the top of the spinal cord. The neurons of the second order are the ganglion cells in the retina whose processes pass into the nerve fibre layer

and along the optic nerve to one of three terminations: most (80 per cent.) end in the lateral or external

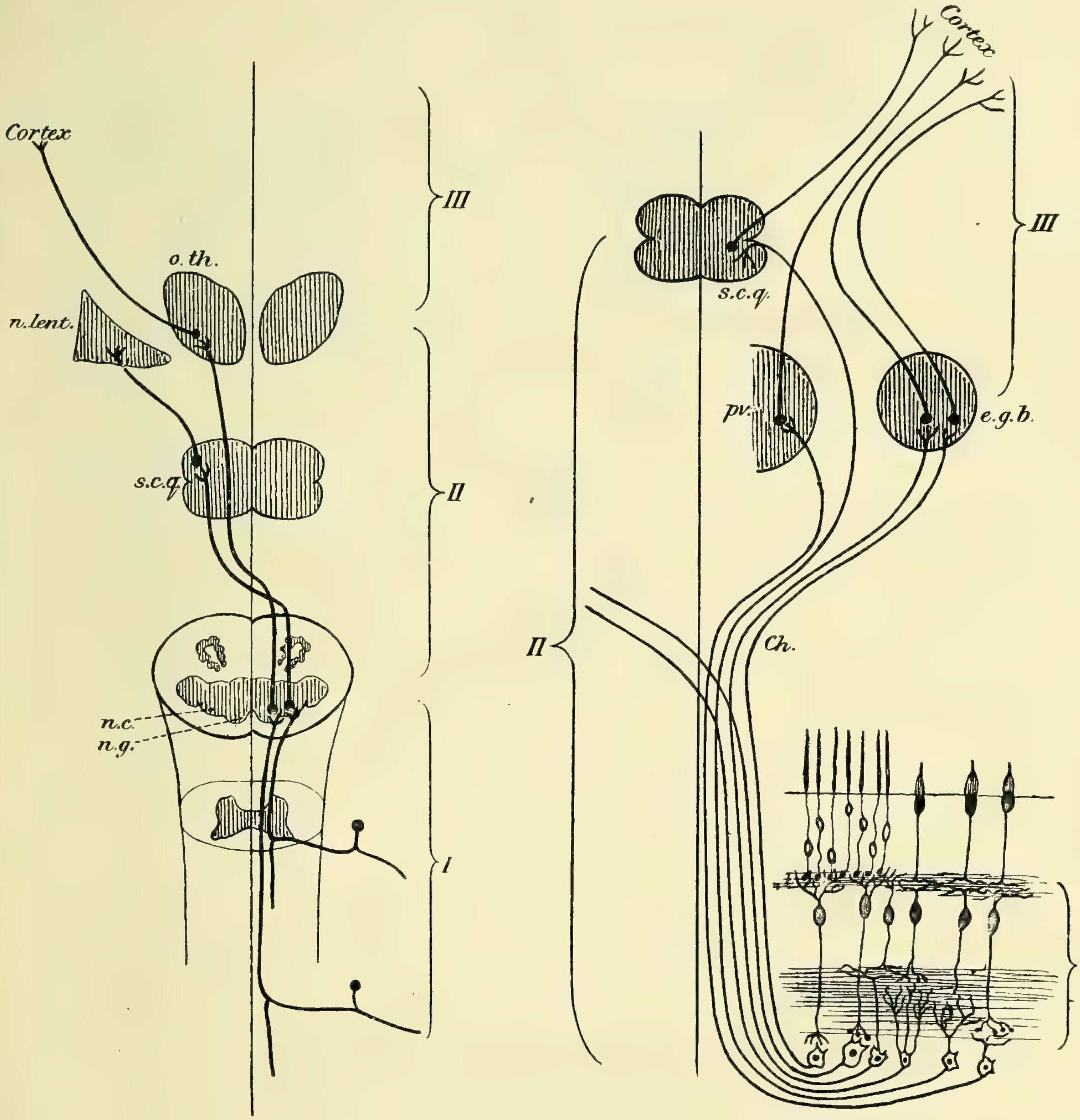

FIG. 56. FIG. 57.

FIGS. 56 and 57.—Fig. 56 represents a diagram of the neurons of the most direct path of common sensation. Fig. 57 represents the neurons of the afferent visual path. I, II, III, neurons of the first, second, and third orders respectively; *n.c.*, nucleus cuneatus; *n.g.*, nucleus gracilis; *s.c.q.*, superior corpus quadrigeminum; *n.lent.*, nucleus lenticularis; *o.th.*, optic thalamus. I in Fig. 57, rod and cone bipolars in the retina. *Ch.*, chiasma; *e.g.b.*, external geniculate body; *pv.*, pulvinar of optic thalamus.

geniculate body, others pass to the optic thalamus, and a few go to the superior colliculus. At these three sites a new cell, the neuron of the third order, takes up the transmission of the impulse, travelling by way of the optic radiations of Gratiolet to the cortex of the occipital lobe, which is the so-called *visual centre.*

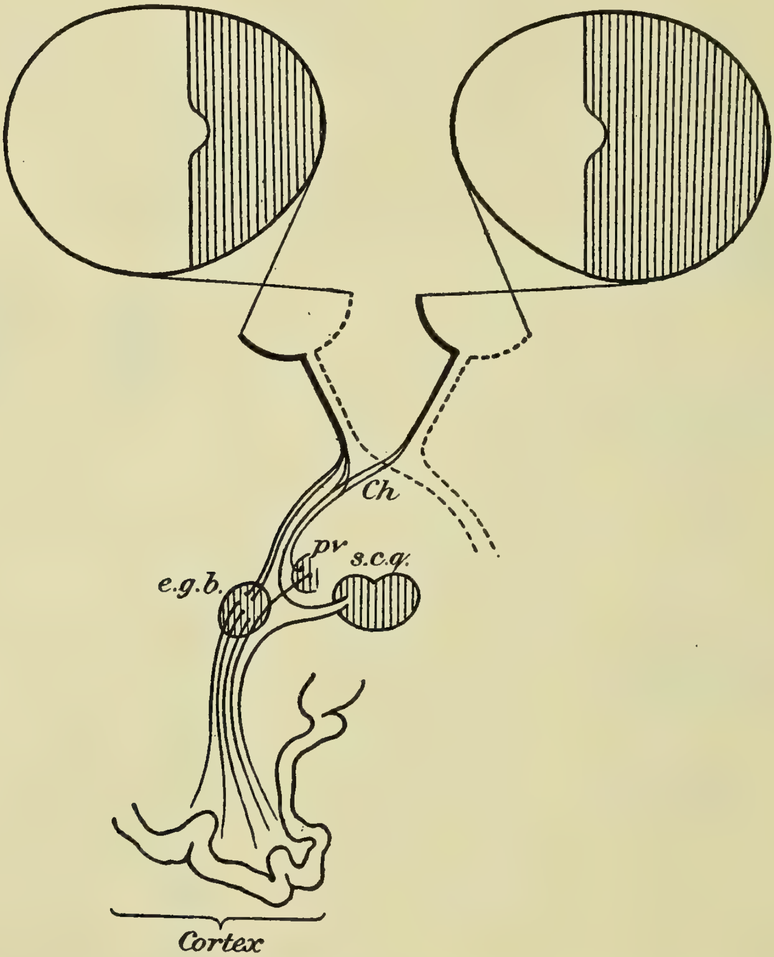

FIG. 58.—Diagram of the afferent visual paths from the retinæ, with the corresponding fields of vision. (After von Monakow.) *Ch.*, chiasma ; *pv.*, pulvinar of optic thalamus ; *e.g.b.*, external geniculate body ; *s.c.q.*, superior corpus quadrigeminum.

We see, then, the morphological identity of the two systems, in spite of the great anatomical differences which specialisation has brought about. We may emphasise again the fact that the peripheral optic nerve

proper is a bipolar cell in the inner nuclear and inner reticular layers of the retina, whilst the so-called optic nerve is a part of the central nervous system homologous with the posterior columns of the spinal cord.

We must now investigate more minutely the individual parts of the visual system. The results which are about to be described are derived from three sources—embryology, experiments upon animals, and clinical observation as controlled by post-mortem findings.

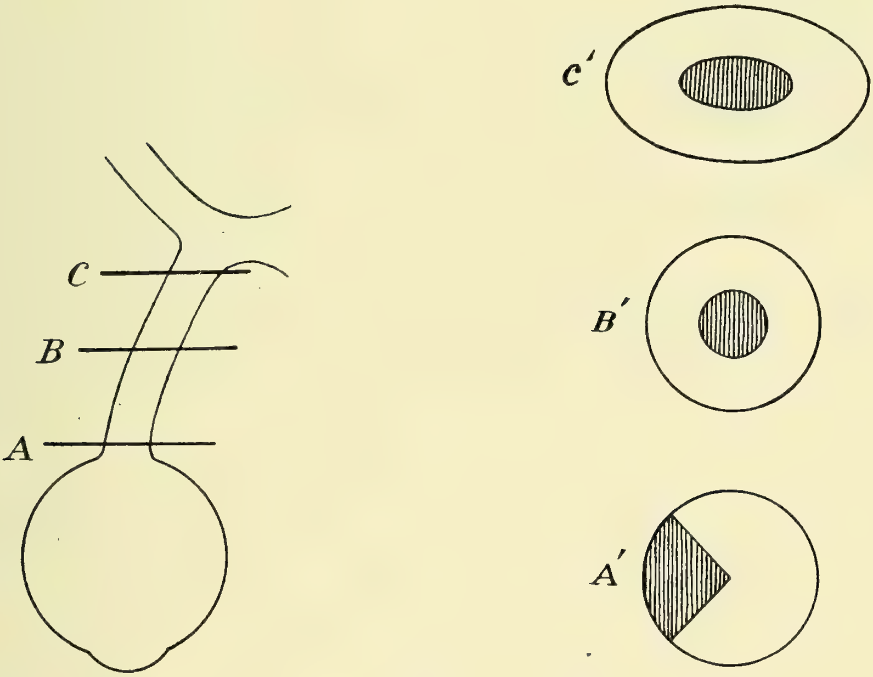

FIG. 59.—Distribution of the papillo-macular fibres in the optic nerve. The shaded areas in A′, B′, C′, represent the papillo-macular bundle in sections corresponding with A, B, and C.

Let us first trace the fibres from the various parts of the retina (Fig. 58). In general it may be said that the fibres from peripheral parts enter the middle of the nerve, whilst the fibres from parts near the nerve enter the peripheral parts of the nerve: they probably maintain this relative position as far back as the chiasma. There is however one disturbing factor, viz., the fibres from the macular region. This part is specially well supplied. The fibres pass into the outer part of the nerve, where they are spread over an area which is triangular in section, with the apex towards the centre of the nerve (Fig. 59). These *papillo-macular fibres* soon become more centrally situated, so that in the posterior part of the nerve they are all in the centre. Tracing them still farther backwards some decussate in the chiasma, whilst others enter the optic tract of the same side. They spread out widely in the two tracts and in the lateral geniculate bodies. The axons of their corresponding neurons of the third order are also widely distributed in the optic radiations and end in the lips of the calcarine fissure of the occipital lobe, probably along its whole length. We see then that each macular region is represented in each occipital lobe, so that no lesion confined to one occipital lobe will abolish central vision in either retina.

The fibres from peripheral regions of the retina, on the other hand, form two distinct groups, corresponding with the temporal and nasal halves of the retina. The limitation is very exact, as if a vertical line divided the retina into two halves at the level of the fovea; since the foveal fibres have a different distribution the line makes a little curve round it so as to avoid it (Fig. 58). The fibres from the temporal half of the retina enter the chiasma but do not decussate; they pass into the optic tract of the same side. Thence they run to the lateral geniculate body, and a few to the thalamus and superior colliculus. The fibres from the nasal half of the retina enter the chiasma, decussate, and pass into the optic tract of the opposite side, having a similar distribution on the other side. The corresponding neurons of the third order pass by the optic radiations to the corresponding occipital lobes. We see, therefore, that a

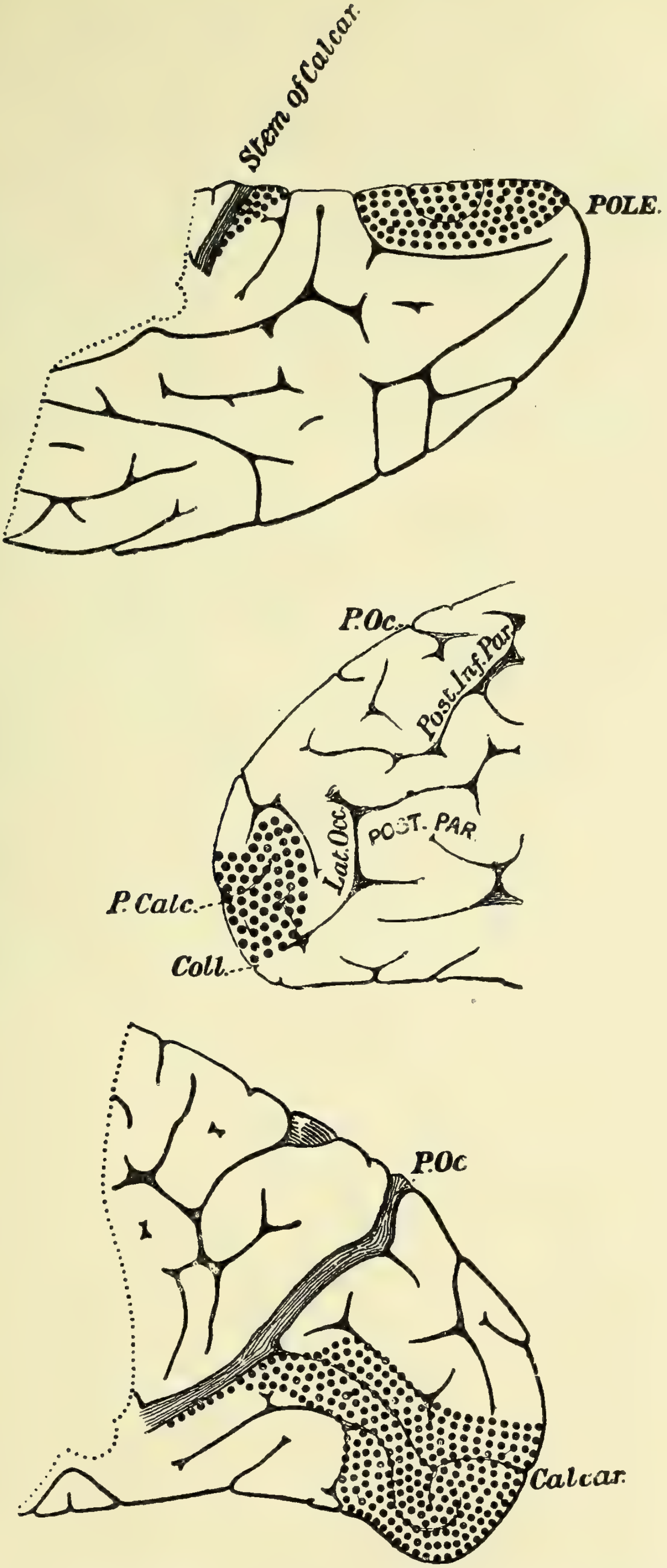

Fig. 60.—Visuo-sensory area of a healthy man of fifty-five. (J. S. Bolton.) *P.Oc.*, parieto-occipital fissure ; *Calcar.*, calcarine fissure ; *Coll.*. collateral fissure.

lesion of one occipital lobe or optic tract will cause blindness of the temporal half of the retina on the same side and of the nasal half of the retina on the opposite side. Projecting this outwards such a lesion will cause loss of vision in the opposite half of the binocular field of vision, a condition which is known as *hemianopia* (hemiopia, hemianopsia). We may recall the fact that the afferent pupil-constrictor fibres have a similar semi-decussation in the chiasma.

The visual fibres in the optic radiations maintain a posterior position in common with the sensory fibres from the rest of the body, being thus situated behind the motor fibres in the internal capsule. They are close to the posterior cornu of the lateral ventricle, so that they are liable to pressure here when the ventricle is distended.

The occipital cortex in and about the calcarine fissure differs from the cortex elsewhere in the possession of a white line, the line of Gennari, interpolated in the grey matter. This area, which is the primary visual or visuo-sensory area (Fig. 60), is the cortical projection of the corresponding halves of both retinæ. In this projection the part above the calcarine fissure represents the upper corresponding quadrants, the part below the lower corresponding quadrants of both retinæ.

It may be mentioned that there are efferent fibres in the optic nerves. They are axons of cells in the lateral geniculate body. Their function is unknown, but they are probably concerned in the movements of the pigment epithelium and of the cones; possibly also in the chemical changes in the visual purple.

SECTION II.

THE EXAMINATION OF THE EYE.

CHAPTER VI.

EXTERNAL EXAMINATION.

Ophthalmic patients may be roughly divided into two groups: those who present manifest objective signs of disease, and those who, presenting no outward and visible signs, have abnormal subjective symptoms. The division is convenient both in theory and in practice. The second group, in all but "functional" cases, have latent objective signs which it is our duty to discover. In the first group the manifest signs may mask even more serious conditions which it is our duty to bring to light. Not infrequently we are confronted with obscure cases which demand the most careful systematic examination in order that nothing may be overlooked. Though it is not always possible, or even necessary, to go through the lengthy routine of an exhaustive systematic examination, yet the details of such a routine must be firmly engrafted in our minds, ready for instant application, if we wish to avoid mistakes in diagnosis.

We shall first describe the methods of examination of the parts which can be observed with the unaided eye, though we shall often ensure accuracy by artificial assistance. Next, we shall describe the methods which must be employed to examine the deeper parts of the eye. Finally, we shall map out a routine of systematic examination.

In the patients who belong to our first group we shall at once be confronted with visible signs of disease. We shall not consider in this place gross signs such as marked protrusion or proptosis, great deviations of the optic axes from the normal parallelism, and so on. These will be more conveniently investigated in their special relations. We shall confine ourselves to conditions affecting the globe itself.

The Conjunctiva.—In the normal position of the lids only that part of the bulbar conjunctiva which is exposed in the palpebral aperture, together with parts of the intermarginal strip along the edges of the lids, is visible. In order thoroughly to investigate the whole conjunctival sac it is necessary to expose the palpebral conjunctiva and the fornices.

The lower fornix is easily exposed by drawing down the lower lid whilst the patient looks towards the ceiling.

The upper palpebral conjunctiva is exposed by everting the upper lid.

Eversion of the upper lid requires some practice. (1) The best, and often the easiest, method is as follows: Stand facing the patient. Place the right index finger horizontally along the patient's left upper lid whilst he looks towards his feet. Draw the skin of the lid outwards: this causes the inner part of the edge of the lid to come forwards, whilst at the same time the pressure of the finger affords a fixed point around which the lid can revolve in a vertical direction. Insinuate the right thumb under the projecting edge of the lid, and roll the lid upwards towards the index finger. The right lid is everted in the same manner, using the left hand.

This method is very easy when the eyes are prominent,

and it causes a minimum of discomfort to the patient. When the eyes are deeply set in the orbit, as is often the case in old people whose orbital fat has become to a great extent absorbed, more pressure is needed and a little pain is caused. In such cases the following method may be adopted; the tyro will generally find it easier:

(2) Place a probe or thin pencil horizontally along the skin of the upper lid at the level of the upper border of the tarsus, the patient looking towards his feet.

Seize the eyelashes between the left index and thumb, and draw the lid away from the globe, using the probe as a fixed point. Rotate the lid in a vertical direction round the probe, which is then withdrawn.

In many cases we wish to evert the upper lid when standing behind the patient, who may be lying on a couch. In this case the following is the best method:

(3) Place the left index finger vertically upon the lid whilst the patient is looking towards his feet. Seize the lashes with the right index and thumb, and rotate the lid around the tip of the left index.

In babies a special arrangement of the patient facilitates thorough examination of the conjunctival sac and eye:

(4) The surgeon sits facing a nurse, who holds the child on her lap. The baby's head is placed between the surgeon's knees; its body is on the nurse's lap. She holds the child's hands against its body, thus keeping them out of the way, and at the same time steadying the child. If, as is often the case, there is blepharospasm, eversion of the lids is extremely easy; indeed, it becomes troublesome when we wish to examine the cornea. Here the spasm of the orbicularis fixes the lids against the globe, and the slightest attempt to draw the lids apart causes both to become everted. When this does not occur, method (3) must be adopted.

Having everted the upper lid we can examine the palpebral conjunctiva, but we are still unable to see the upper fornix. This can usually be effected in adults by the following manœuvre: (1) With the lid still everted by the first method it is fixed in that position by the left thumb placed upon its margin at about the middle. The right thumb or finger is placed in the middle of the lower lid. Firm, steady pressure is then made through the lower lid upon the globe in a direction straight backwards, as if to push the globe into the orbit. In the meantime firm pressure is also exerted backwards upon the upper lid with the left thumb. The fornix will generally start forwards suddenly, but only if the patient keeps looking well down towards his feet all the time.

This method, though unpleasant, is not painful. The only other method of exploring the upper fornix is more effectual, but also painful. The eye should therefore be well cocained.

(2) The upper lid is everted in the usual manner. A retractor is then inserted under the everted lid into the fornix. The margin of the lid being fixed as in (1), the lid is everted a second time, so that the fornix is fully exposed. Sometimes it is necessary to grasp the everted lid with forceps and thus evert it a second time.

By these manœuvres the conjunctival sac can be thoroughly explored. Special attention must be paid to the favourite sites for foreign bodies and manifestations of disease, *e.g.*, foreign bodies often lodge on the palpebral conjunctiva about 2 mm. from the margin at about the middle of the lid; trachoma follicles are most marked in the upper fornix; scarring from old trachoma is most marked in the palpebral conjunctiva, &c. Adhesions between palpebral and ocular conjunctiva and obliteration of either fornix cannot fail to be noticed. Inflammatory conditions can be thoroughly examined; accurate diagnosis often depends upon minute

investigation. Patches of granulation tissue which bleed easily may mark the site of embedded foreign bodies, or, if on the palpebral conjunctiva, the site of a chalazion.

The ocular conjunctiva can be almost completely examined without everting the lids if the eye is moved up and down whilst the lids are kept apart. The redness which is observed in irritative and inflammatory conditions varies in its distribution and nature according to the cause. Here we must remember the groups of vessels with which we have to deal (*vide* p. 14). Three groups may be distinguished, though most of them are too small to be recognised in health: (1) the proper vessels of the conjunctiva or posterior conjunctival vessels (Plate II.); (2) the anterior conjunctival vessels, which supply the area adjacent to the limbus or corneal margin and send minute loops into the edge of the cornea itself (*vide* p. 17; Fig. 61); (3) the anterior ciliary vessels, lying in the subconjunctival or episcleral tissue. In the last group the perforating branches of the arteries are seen in health as

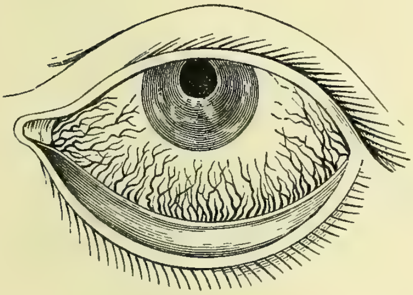

FIG. 61.—Conjunctival congestion — engorgement of the posterior conjunctival arteries and veins. (After Guthrie.)

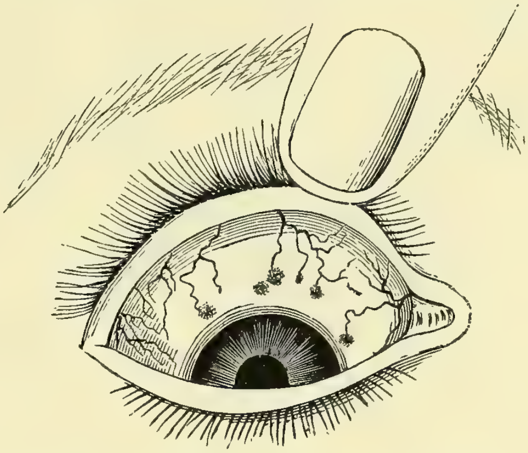

FIG. 62.—Congestion of the perforating branches of the anterior ciliary arteries. (Dalrymple.) The dusky spots at the seats of perforation are often seen in dark-complexioned persons.

several comparatively large tortuous vessels which suddenly cease about 2 to 4 mm. from the corneal margin. They have very numerous small episcleral branches which are invisible in health, but when dilated form a pink zone of fine, straight, very closely set vessels around the cornea. The corresponding perforating veins are very small, but more numerous than the arteries; their episcleral branches form a closely-meshed network.

Congestion of the individual groups of vessels affords important evidence as to the seat of the mischief. The conjunctival vessels can be distinguished from the anterior ciliary by the following points: (1) they are a brighter brick-red, the ciliary vessels being seen through the conjunctiva, which imparts a purple tinge; (2) if the conjunctiva is moved to and fro over the sclerotic by the finger placed on the lower lid the conjunctival vessels also move whilst the ciliary remain stationary; (3) the individual vessels and the network they form can be seen in the conjunctival system, whereas the ciliary form for the most part a diffuse reddish violet blush in which the separate vessels are indistinguishable; (4) if the blood is pressed out of the vessels the ciliary fill up at once on

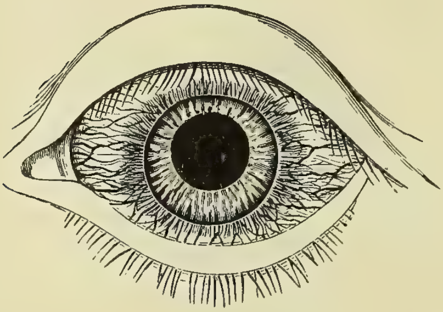

FIG. 63. — Ciliary congestion — engorgement of episcleral twigs of the anterior ciliary arteries. (After Dalrymple.)

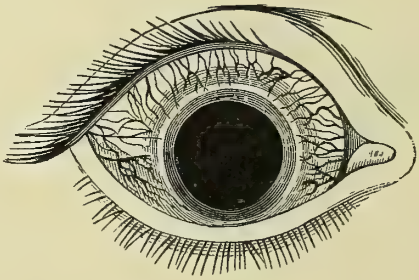

FIG. 64. — Congestion of the anterior ciliary veins, episcleral venous plexus. (After Dalrymple.)

removing the pressure, since they anastomose very freely, whilst the conjunctival fill slowly.

In general, congestion of the conjunctival vessels, leaving a relatively white zone around the cornea, accompanied by mucous or muco-purulent secretion, is indicative of conjunctivitis. If there is much irritation and so-called photophobia, with some blepharospasm and very watery—lacrymal—secretion, we suspect the presence of a foreign body on the cornea or under the lid, so that it rubs against the cornea: the condition may be due to misplaced lashes (trichiasis). Phlyctenular ophthalmia may produce a similar picture. In such a case there is also usually congestion of the anterior conjunctival vessels. Careful examination shows that the vessels in the circumcorneal zone are bright red, and that the corneal loops are also dilated and visible. Any irritation of the cornea—ulcers, abrasions, &c.—causes this conjunctival congestion of the circumcorneal zone and corneal vessels. Though conjunctival they do not move with the membrane. A definite leash of dilated vessels confined to the conjunctiva or encroaching upon the cornea is usually indicative of phlyctenular disease.

Pink circumcorneal congestion is also met with in inflammation of the iris. Here the anterior ciliary vessels are also involved.

Circumcorneal congestion of a peculiar lilac tint, more deeply seated and often patchy, is associated with cyclitis and deep scleritis. This is the condition which is known as ciliary congestion par excellence.

Dusky congestion at the limbus, composed of a fine reticulum—the episcleral venous plexus—often points to glaucoma, but may accompany other diseases, especially in old people.

These conditions run into one another very frequently, so that they then cease to have special diagnostic importance.

Lacrymal Apparatus.—Conjunctival congestion of one eye only, or signs of irritation such as watering, should lead us to suspect the efficiency of the lacrymal apparatus. Simple epiphora or flow of tears on to the cheek may be due to blocking of one or both puncta or to their malposition, or to blockage elsewhere in the canaliculi or nasal duct. Displacement of the lower punctum may be easily overlooked. The puncta are not visible normally without slightly everting the lids. Displacement is often very slight, due to slackness of the lid causing a little rolling out or ectropion, especially in old people. In spasm of the orbicularis the lid may be rolled in too much (entropion); this may also cause epiphora. Sometimes with more conjunctival inflammation, but often without, there is distension and chronic inflammation of the lacrymal sac. In all such cases we carefully observe the exact position of the puncta, whether they are in apposition to the bulbar conjunctiva as they should be, and also whether there is any regurgitation from the lacrymal sac when it is pressed upon. The lacrymal sac is situated in the lacrymal fossa between the inner canthus and the nose: the fundus extends slightly above the level of the inner palpebral ligament, which is on a line with the canthus. Pressure inwards and backwards in this position will press upon the sac. If there is any obstruction to the flow of the contents into the nose by the nasal duct, as is usually the case when the sac is inflamed, the contents will generally regurgitate into the conjunctival sac by way of the canaliculi, and will be seen pouring from the puncta. We note whether the contents are tears, mucus, or muco-pus.

Without describing special methods of ascertaining if the lacrymal passages are patent (Chap. XXX.), a simple test may be mentioned. A drop of fluorescein solution is placed in the conjunctival sac and the patient is told

to blow his nose. If the passages are free, the handkerchief will be stained with the solution.

The Sclerotic.—Inspection of the sclerotic around the cornea may reveal raised nodules of episcleritis with their localised areas of vascular congestion (*vide* p. 277). Deep scleritis may be shown by dusky ciliary congestion and opacification of the deeper layers of the cornea at the periphery (sclerosing keratitis, *vide* p. 280).

Definite blue coloration of the circumcorneal sclerotic, except in young children, is pathological. It is most frequently due to ciliary staphyloma, a giving way of the sclera owing to inherent weakness (injury, scleritis, &c.) or to increased intraocular pressure (glaucoma). Discoloration may be due to pigmentation. Slight duskiness around the spots where the anterior ciliary vessels perforate is not uncommon in people with dark complexions. Otherwise pigmentation in this neighbourhood, either in the conjunctiva or sclerotic, should be regarded with suspicion as indicative of melanotic sarcoma. Definite nodules of deeply pigmented tissue in the situation of the perforating vessels is very significant of sarcoma of the ciliary body.

If there is bulging of the sclerotic an attempt should be made to transilluminate it in the dark room. If it is a true ectasia (staphyloma) light will pass through into the eye. The light should be concentrated upon the spot by a strong lens (*vide* p. 101).

The abrupt or very gradual curvature of the sclerotic as it passes back from the cornea may indicate high hypermetropia or myopia respectively.

The Cornea.—A little experience will enable us to recognise at a glance if the cornea is smaller than usual. A small cornea with a shallow anterior chamber is very suggestive of glaucoma.

The cornea should be bright and transparent. We first examine its surface. Any loss of substance, such as an abrasion, may easily be overlooked without special care. The condition of irritation and lacrymation will often put us on the track, but these features may be so slight as to pass unnoticed. The following methods should be adopted :

(1) Place the patient facing the window. Stand in front and direct the patient to follow the index finger, which is held horizontal and moved slowly up and down. The finger is then held vertical and moved from side to side. Whilst these manœuvres are being carried out the image of the window or corneal reflex, as it is called, is carefully watched. If the surface of the cornea is normal there will be no distortion of the reflex as it passes over it. If there is an abrasion the image will be distorted here, and will be less clearly defined. This method should always be resorted to first, as it is good practice in observation and needs no artificial aid which may not be available under some circumstances.

(2) If the first method gives uncertain results or fails, instil a drop of fluorescein solution (2 per cent.). This is best done by telling the patient to look towards his feet; the conjunctiva above the cornea is then lightly touched with the tip of a glass rod which has been dipped in the solution. A pad of cotton wool is immediately placed upon the closed lids so as to mop up the excess and the tears which tend to flow over the face. If this detail is not attended to the face becomes stained unnecessarily. It is a good plan to wash out the excess of fluorescein with a drop of cocain solution, but it is not essential. Any spot on the surface of the cornea which is denuded of epithelium will appear green.

A bundle of dilated conjunctival vessels near the limbus will often mark the site of a foreign body upon the cornea.

Opacities of the cornea may be so faint that they require very minute investigation, and the same is true of the details—depth, &c.—of gross opacities. We can study them best by focal or oblique illumination.

Focal or oblique illumination is carried out as follows (Fig. 65): the patient is placed, preferably in the dark room, with a light about two feet in front but slightly to one side. The light is concentrated upon the cornea by a strong convex lens (the large lens in the ophthalmoscope case). The rays of light are brought to a focus by the lens. The cornea or other superficial structures

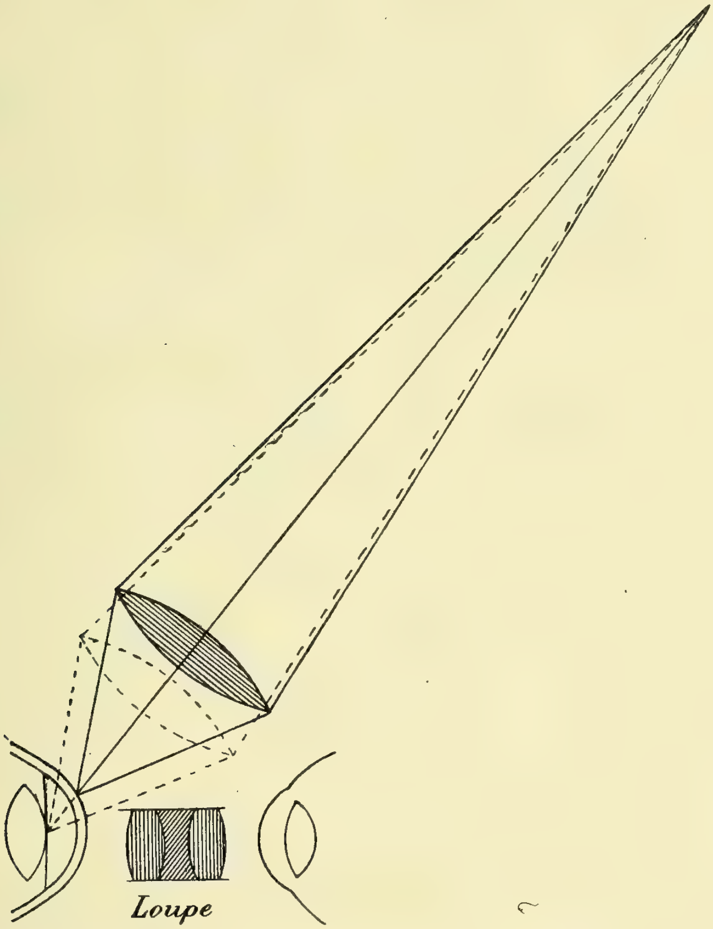

FIG. 65.—Focal or oblique illumination. The diagram shows how the focus of the light may be altered by slightly shifting the position of the concentrating lens.

can thus be examined under the intense light of the converging rays. The position of the minute image of the light formed by the lens can be moved over the surface of the cornea by slight lateral movements of the lens without altering the position of the light. Similarly the light may be focused upon the iris or crystalline lens by moving the lens slightly nearer to the eye.

Having thus brilliantly illuminated the part of the cornea which we wish to investigate, we may magnify the spot by looking through a very strong convex lens or corneal loupe held in the other hand. The management of the two lenses requires a little practice, but is easily mastered. A few words of explanation about the corneal loupe will help us to employ it to best advantage.

When we magnify a small object with a strong convex lens we place it within the focal distance of the lens and view it through the lens. We know that under these conditions the lens forms an enlarged image upon the same side as the object, but farther away (*vide* p. 34, Fig. 21). In order that we may see the image to best advantage we must see as much of it as possible, and we must see it under the largest possible visual angle. The first requisite demands that the observer's eye shall be as close to the lens as possible. The second requisite depends upon the relative distances of the object and the eye from the lens; in practice these are found by slight movements of the lens.

In employing focal illumination, then, first focus the light upon the required spot. Then place the corneal loupe near the spot and look through it. Slowly advance the loupe towards the cornea until the spot comes into focus. Then get the eye as close to the loupe as possible. In this manner we shall see all there is to be seen.

By moving the light and the loupe slowly over the whole surface of the cornea we can thoroughly explore it.

By advancing the convex lens we can illuminate successively the back of the cornea, the iris and anterior part of the lens, and finally the deeper parts of the lens. By simultaneously advancing the position of the loupe towards the cornea we can successively bring these structures into accurate focus and examine them under considerable magnification. We cannot get beyond the back of the lens with a high power loupe, as it works at too short a focal distance. Moreover, in order to examine the deeper parts of the lens we must have the light almost in front of the patient, otherwise they will not be illuminated.

Focal illumination without the assistance of a loupe or a dark room is often of great advantage through the good illumination which it affords. One soon gets into the habit of concentrating the light from the window upon the eye with the convex lens with a view to improving the optical conditions.

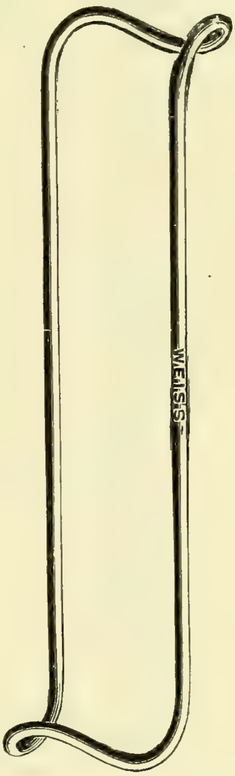

FIG. 66.—Bent wire lid retractor.

The cornea is often affected secondarily to the conjunctiva, as in phlyctenular ophthalmia. In such conditions the eye is most irritable and resistant to examination in bright light. The slightest attempt to separate the lids is accompanied by violent blepharospasm, especially in children. Yet it is in such cases that it is of the greatest importance to know and watch the condition of the cornea. For aught we know it may be ulcerated, and may even be upon the point of becoming perforated. Any roughness, or even an amount of pressure which is quite justifiable in other cases, may suffice to cause the perforation which it should be our chief effort to avoid. In such a case the lids must be separated by retractors. We may use simple bent wire retractors (Fig. 66) or Desmarres' retractor (Fig. 67). In babies the position recommended in method (4), p. 93, is employed: older children are placed upon a couch. The retractors are inserted gently into the palpebral aperture, first the upper, then the lower, the curved ends being insinuated between the lids and the globe. Traction is then made upon the retractors, not only in opposite directions up and down, but also away from the globe, so that the lids are lifted off the globe at the same time that they are separated. In these cases the globe tends to roll forcibly upwards when light falls upon it, which makes it very difficult to see the cornea even with the use of retractors. The difficulty may be overcome by pressing the end of the lower retractor well into the lower fornix, which drags the eye downwards by pulling on the ocular conjunctiva.

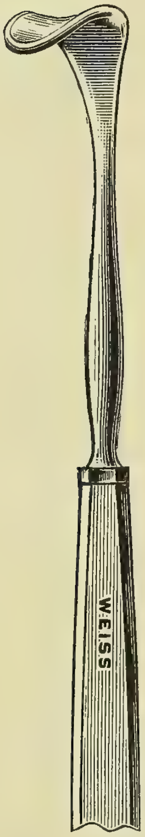

FIG. 67. — Desmarres' lid retractor.

When we have satisfied ourselves that there is little or no fear of perforation we may dispense with retractors. It has been pointed out that in children an attempt to separate the lids when there is much blepharospasm is usually followed by eversion of both lids, the cornea still remaining hidden. The way to overcome this difficulty is to place the two thumbs close to the edges of the lids and to press gently but firmly upon the globe as the lids are drawn apart. In this manner they are separated without becoming everted, but we must be extremely careful not to exert undue pressure and not to touch the cornea with the thumb nails.

In many diseases new vessels are formed in the cornea.

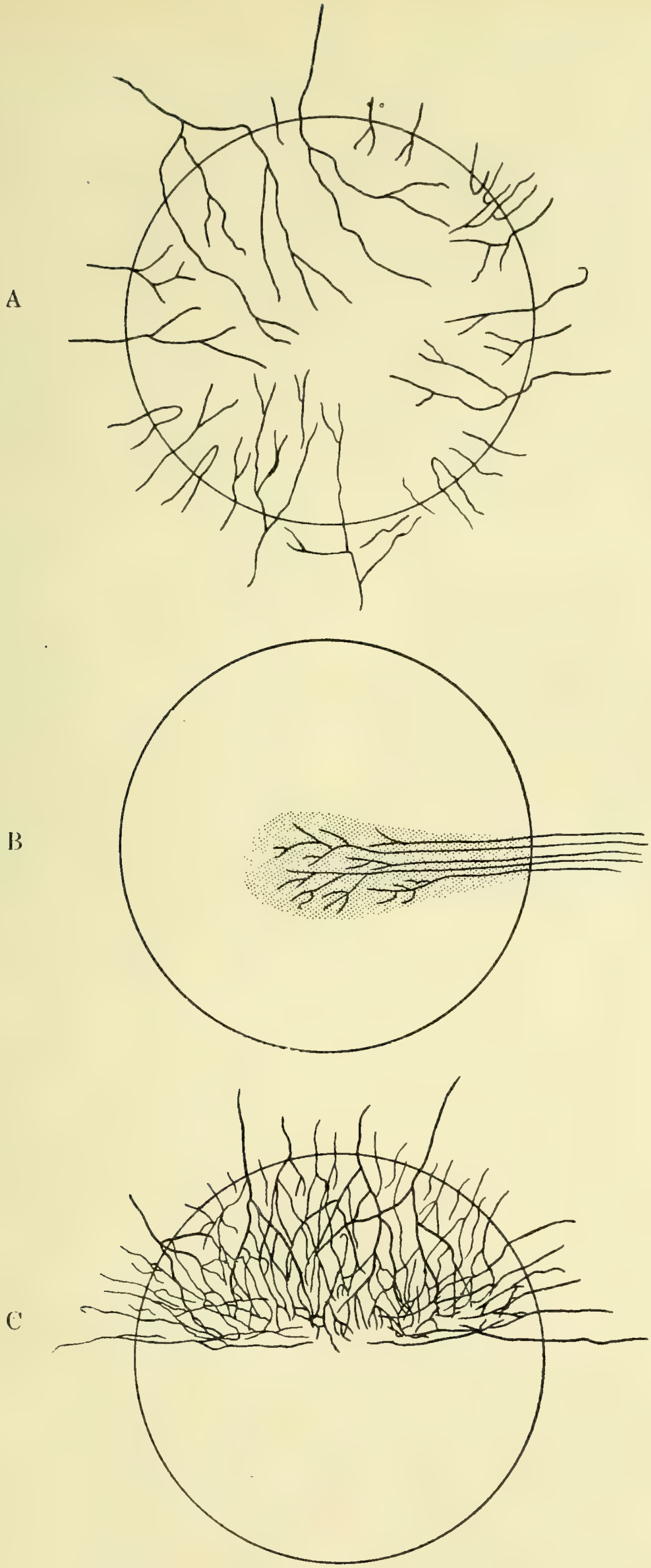

FIG. 68.—Diagrams of superficial corneal vessels. A, general vascularisation ; B, a single leash of vessels, as in fascicular ulcer (*vide* p. 250) ; C, localised vascularisation, as in trachomatous pannus (*vide* p. 203).

An exact knowledge of their position, whether superficial or deep, and of their distribution, whether localised, general, peripheral, above, and so on, will often settle a disputed point in diagnosis.

Superficial vessels (Fig. 68) in the cornea are distinguished from deep (Fig. 69) by the following features: (1) superficial vessels can be traced over the limbus into the conjunctiva, whilst deep ones seem to come to an abrupt end at the limbus; (2) superficial vessels are bright red and well defined, whilst deep ones are ill defined, greyish red, or cause only a diffuse red blush; (3) superficial vessels branch in an arborescent fashion, dichotomously, whilst deep ones run more or less parallel to each other in a general radial direction, and branch at very acute angles, like a besom; (4) superficial vessels may raise the epithelium over them so that the surface of the cornea is uneven, whilst with deep ones the cornea, though hazy, is smooth.

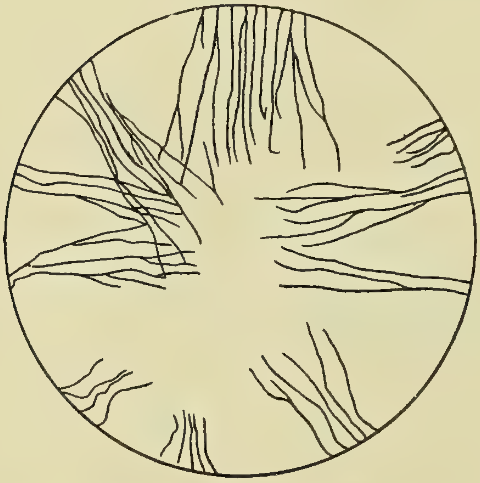

Fig. 69.—Diagram of deep corneal vessels, as in interstitial keratitis (*vide* p. 261).

The Anterior Chamber.—The anterior chamber is shallow in extreme youth and in old age; at other periods of life it is about 2·5 mm. deep normally. It must be remembered that we estimate the depth of the anterior chamber by the position of the iris, and that we view the iris through the cornea, which is a strongly refracting convex surface. The effect of this is to magnify the iris and pupil, and to make it appear farther forwards than it really is. The same applies to anything in

L The peculiar course of the deep vessels is probably determined by the lamellar structure of the substantia propria.

the anterior chamber, *e.g.*, the point of a knife in operations.

Good binocular vision enables us to estimate the depth of the anterior chamber when we are looking at it from in front. The observation should be confirmed by taking a profile view.

The anterior chamber is abnormally shallow in glaucoma. It is often abnormally deep in irido-cyclitis. It is frequently unequal in depth in different parts. For example, it may be deeper at the periphery than in the centre in irido-cyclitis; on the other hand, when the iris is bowed forwards (iris bombé) it is funnel-shaped, the centre being deep, the periphery very shallow.

After considering the depth, attention must be paid to the contents. In some wounds and ulcers of the cornea, and rarely without them, there is pus in the anterior chamber. It forms a layer at the bottom, the surface of the pus being level (hypopyon). A similar layer of blood may occur after contusions or spontaneously (hyphæma). The aqueous may be hazy, a condition not always easy to distinguish from haziness of the cornea. Such cases lead us to examine very carefully the back of the cornea with the loupe under focal illumination to see if there are any precipitates ("keratitis punctata") upon it, or we may see flocculent specks in the aqueous. All these conditions are of great diagnostic and prognostic importance.

The Iris.—We pay attention first to the *colour* of the iris and the clearness of its pattern. The two irides or parts of the same iris may be of different colour, both conditions being known as heterochromia iridis. Dark brown spots in the iris, not raised above the surface, are common. Care must be taken to distinguish them from small ~~tumours~~ of the same colour or white (sarcoma, tubercle, gumma). "Muddiness" of the iris is the nodul expression used for indistinctness of the pattern, caused by inflammatory exudates. A muddy iris, with small irregular pupil and sluggish reaction to light, is indicative of iritis.

The *position* of the iris must be noted, especially the plane in which it lies (*vide* pp. 291, 301, 311). Special attention should be paid to any adhesions (synechiæ) anterior—to the cornea, or posterior—to the lens capsule. *Tremulousness* of the iris (iridodonesis) is seen when the eyes are moved rapidly if the iris is not properly supported by the lens, *e.g.*, in absence, shrinkage, or dislocation of the lens, slackness of the suspensory ligament, &c. It is best seen in a dark room with oblique illumination.

The Pupils.—A point which should be examined at an early stage in every routine examination of the eyes is the condition of the pupils. This is the more important since the routine examination frequently demands the use of a mydriatic, and if the pupils have not previously been noted it may be necessary to require the attendance of the patient on another occasion when the effect of the mydriatic has passed off.

The examination of the pupils requires careful attention to details if trustworthy results are to be obtained. It is best carried out as follows :

Place the patient facing the light, which should not be too bright ; see that the two pupils are equally illuminated. Note the size, shape and contour of each pupil. Cover both eyes with the palms of the hands, preferably without touching the face. Tell the patient to look straight at you. Remove one hand and watch the pupil. Replace this hand and remove the other, watching the other pupil. Note down and compare the results (*direct reaction to light*). Remove one hand so that this eye is exposed to light (it should be shaded from intense light). Watch this pupil as the hand is removed from the other eye. Repeat the

process whilst watching the other pupil (*consensual reaction to light*).

Now tell the patient to look quite across the room, as far off as possible. Suddenly hold up the index finger vertically at about six inches from the patient's nose, and tell the patient to look at it. Watch the pupils while he accommodates for the finger (*reaction to accommodation*).

When the reaction to light is feeble and the pupils are already small, it is difficult to be certain of the results in bright diffuse daylight, the corneal reflexes adding to the difficulty. In such cases the patient should be taken into the dark room and the light concentrated upon one pupil by focal illumination. By a slight lateral movement of the convex lens (*vide* p. 101) the focus of light can be moved on or off the pupil, the pupillary movements being watched the while. If there is no movement under these conditions we may conclude that the reaction to light is absent.

It is better not to use the ophthalmoscope mirror in this procedure, as the patient is very likely to look at it, and a reaction to accommodation may be mistaken for one to light. Note very carefully if the constriction of the pupil to light is well maintained (*vide* p. 407).

The same method will elicit the *hemianopic pupil reaction* (Wernicke) in the rare cases (lesion of one optic tract) in which it is present. To test for it, the light is placed in front, but rather to one side of the patient. The light is focused with the lens upon the opposite side of the retina, and the pupil watched. The light is then moved to the other side and is now focused on the other side of the retina. If the reaction is present the pupil will react briskly when one half of the retina is illuminated, but very slightly or not at all when the other half is illuminated. It usually reacts slightly even in the latter case, owing to the impossibility of preventing diffusion of light on to the sensitive half of the retina, and for this reason the test is rarely unequivocal.

When the pupils are small to start with ("spinal miosis"), do not react to light, but react to accommodation, the condition is known as the *Argyll Robertson pupil.* It occurs especially in para-syphilitic disease, most commonly and in its most characteristic form in tabes, and frequently in general paralysis of the insane; but it is also found in other syphilitic diseases of the central nervous system.

If the above directions are carried out we shall have reliable information as to the shape and relative size of the pupils and their reactions. A few of the commoner conditions may be enumerated here.

Very large pupils will suggest that a mydriatic has been used. It is not uncommon for it to have been used inadvertently. We not infrequently see a patient with the right pupil widely dilated complaining of dimness of vision. Inquiry will often elicit the fact that he has been using a liniment for rheumatism. The explanation is that the liniment contained belladonna, and that after using it with his right hand he rubbed his right eye with the soiled fingers. Often patients use ointment or drops prescribed for other patients. We must always be on our guard against such traps. These pupils are usually quite immobile, and the patient complains of dimness of vision, especially in near work.

The pupil is also large and immobile in complete atrophy of the optic nerve: this may be due to absolute glaucoma. In acute glaucoma it is usually large, immobile, and oval with the long axis vertical; the condition is generally unilateral. If only one eye is blind from disease of the optic nerve this pupil is rather larger than its fellow as a rule, but the consensual reaction to light on the sound eye is much increased, granted of course that the third nerve is intact. Dilatation of the pupils with

retained mobility is found sometimes in myopia and in conditions of impaired nerve tone, *e.g.*, anæmia; it is also found in cases of disseminated sclerosis with optic atrophy, which rarely if ever leads to complete loss of sight in this disease. Dilatation as a reflex to painful impressions has already been mentioned. Unilateral dilatation may result from irritation of the cervical sympathetic in the presence of glands in the neck, pneumonia, phthisis, chronic pleurisy, thoracic aneurism, &c., but it is rare from this cause: it may also be due to syringomyelia, acute anterior poliomyelitis and meningitis affecting the lower cervical and upper dorsal part of the spinal cord and to pressure on the sympathetic fibres leaving the cord in the lower cervical and upper dorsal ventral roots. Temporary dilatation of one pupil is not very uncommon. Unilateral dilatation with immobility may result from a blow on the eye (Chap. XXI.).

The pupils are small in babies and in old people. When the pupils are small, as under the influence of bright light, the relation to the centre of the cornea can be best seen: the centre of the pupil is usually a little to the nasal side of the centre of the cornea. Small pupils are rarely perfectly round. A small immobile pupil should make us suspect old iritis with posterior synechiæ, and should lead to investigation with a mydriatic—homatropin for diagnostic purposes—to see if the pupil dilates regularly. Bilateral small immobile pupils make us suspect disease of the central nervous system (*e.g.*, pontine hæmorrhage); further examination may show that the immobility is confined to reaction to light (*vide* p. 110). A small sluggish pupil, with muddiness of the iris, is associated with iritis, which may be primary or secondary to corneal trouble.

Very small immobile pupils suggest the use of drugs, either locally, *e.g.*, eserin, or through the general system, *e.g.*, morphia.

The chief causes of inequality of the pupils have already been mentioned incidentally. As indicative of central nervous disease it is found in general paralysis.

We must note carefully the nature of the contraction when the pupil reacts to light, and especially if the constriction is well maintained (*vide* p. 407).

The Lens.—The lens cannot be thoroughly examined without the assistance of the ophthalmoscope. By inspection, aided if necessary by focal illumination, we note any opacities in the pupillary area. The pupil may be blocked with iritic exudates (inflammatory pupillary membrane, blocked pupil).

Opacities in the lens itself are seen by oblique illumination as grey, white or yellowish patches. According to their distribution and nature we diagnose the various forms of cataract, but our observations must always be confirmed and controlled by ophthalmoscopic examination. The following example will show how easily one may be led astray. When the light is concentrated by focal illumination upon the pupil of a young person's eye the lens substance seems almost perfectly clear; at most we see a faint bluish haze. If we examine the lens of an old person in the same manner the haze is much more pronounced; the lens substance in fact looks slightly milky. We might conclude that the patient has cataract. Examination with the ophthalmoscope will, however, show a perfectly clear red reflex. The explanation is that the lens substance becomes more optically dense, *i.e.*, the refractive index increases, as the person grows older (*vide* p. 62). Now the higher the refractive index of a substance the greater will be the reflection from its surface. The milkiness which we see is due to rays of light which are reflected from the lens and enter our eyes. The more rays reflected the more will the lens appear milky.

If, however, the white appearance is very pronounced,

⑤ ¶ Instruments known as tonometers have been devised for measuring the tension of the intact eye. ~~2 types in clinical use~~ ~~[illegible]~~ They are far less reliable than the manometer, but this cannot be used on the human eye. The best tonometer for clinical use is that invented by Schiötz. ~~But~~ With it the depth of the indentation in the cornea made by a weighted stylet is measured by a lever which travels over a scale. There are four weights (5.5, 7.5, 10 & 15 gms.) ~~[illegible]~~ & the greatest accuracy is attained with the weight which gives a deflection of the lever of 2 to 4 mm. The instrument is calibrated so that the equivalents of the readings in mm. Hg can be read off a chart.

(run on)

~~¶ Instruments known as tonometers have been devised for measuring the tension of the eye. The best reliable for clinical use is Schiötz tonometer.~~

It is doubtful whether the readings are accurate when transformed into pressure in ~~[illegible]~~ millimeters of mercury, but the tonometer is certainly useful for comparative measurements, e.g., between the two eyes, or between ~~[illegible]~~ successive measurements in the same eye.

and especially if it is strictly localised to certain parts of the lens substance, we may safely diagnose cataract. A spot in the centre of the pupil, looking as if it were on the surface of the lens, may be a pupillary exudate or an anterior polar cataract. Triangular spokes of opacity with their apices towards the centre are indicative of senile cataract. A very white appearance over the whole pupillary area suggests a total cataract; if it is yellow and the iris is tremulous we suspect a shrunken calcareous lens.

The Tension.—Last in the external examination, but by no means of least importance, we test the tension of the eye. It is done in the same manner as testing for fluctuation in other parts of the body.

Stand facing the patient, who is told to keep looking towards his feet. Place the index fingers of both hands side by side upon the upper lid, steadying them by the other fingers lightly applied to the brow. Keep one finger quite still, pressing upon the globe through the lid. Now attempt gently to indent the globe with the other finger, pressing directly downwards, concentrating the attention meanwhile on the impression which is conveyed to the stationary finger. Repeat the process on the other eye.

The student should practise this manœuvre on a number of healthy eyes. He will thus obtain a mental estimate of what is to be considered normal tension—Tn. In absolute glaucoma the eye is usually stony hard; this condition is generally indicated by the convention T + 3, a misuse of numbers, but one in common use. The gradations of increased tension from Tn to T + 3 are usually indicated by the conventions T full (T +), T + 1, T + 2. Similarly the gradations of diminished tension are represented by T minus (T −). T − 1, T − 2, T − 3.

⑤

CHAPTER VII.

OPHTHALMOSCOPIC EXAMINATION.

THE internal parts of the eye beyond the lens cannot be seen without the assistance of the ophthalmoscope. A little consideration of the optical conditions of the eye will show the reason.

Under ordinary circumstances the pupil looks black, and no red reflex, much less a clear image, is obtained from the fundus. If, as in Fig. 70, there is a source of light, L, in front of the eye, and the eye is focused upon it or accommodated for it, the light and a spot upon the retina are conjugate foci; *i.e.*, the image of the spot of light is a spot on the retina. Reversing the direction of the rays, all rays from the illuminated spot of the retina are brought to a focus at the source of light. Therefore no rays will enter an observing eye unless it is situated actually at the source of light. The problem solved by von Helmholtz when he ~~discovered~~ the ophthalmoscope (1851) was practically that of making the observing eye at the same time the source of illumination of the observed fundus.

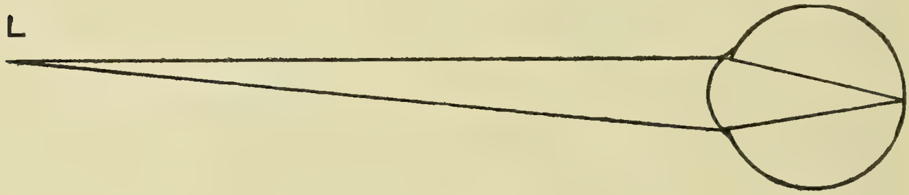

FIG. 70.

If the eye is not focused for the source of light the conditions are different, and some slight luminosity of the pupil may be seen. This is one cause of luminosity

[Babbage (1848) & rediscovered by

in the pupils of the hypermetropic eyes of young children and most carnivora. Extreme hypermetropia is also the cause of the so-called amaurotic cat's eye, which is due to detachment of the retina, glioma of the retina, &c. In these cases the retina is pushed forwards and the fundus at this spot becomes highly hypermetropic, the reflex from the pupil being often the first symptom noticed. The same principle applies to the reflex from the eye after the lens has been removed by extraction of cataract.

In hypermetropia the conjugate focus of the source of light, L, is a point, l, behind the retina (Fig. 71). Hence

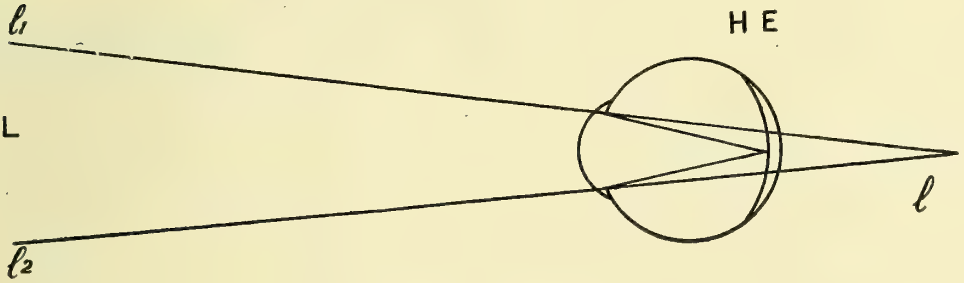

FIG. 71.

the emergent rays from the illuminated area of the fundus are divergent, as if coming from l. Therefore an observing eye situated anywhere within the area l_1 l_2 of the cone of emergent rays will catch some of them, and the pupil of the observed eye will appear feebly illuminated. Under these circumstances it is not necessary for the observing eye to occupy the exact position of the source of light, but only a spot in its immediate neighbourhood. On the same principle, the extremely hypermetropic retina in glioma retinæ, &c., can be seen well by focal illumination.

In high myopia the emergent rays are strongly convergent, and become divergent after coming to a focus at the remote point (Fig. 34). Beyond this point some of the divergent rays may enter an observing eye suitably situated and the observed pupil appears illuminated.

The luminosity of albinos' eyes is due to light entering the eye, not only through the pupil, but also through the iris and sclerotic. That this is the true explanation is shown by the fact the pupil looks black if it is observed through a small hole in an opaque screen. A small amount of light passes through the sclerotic in the normal eye.

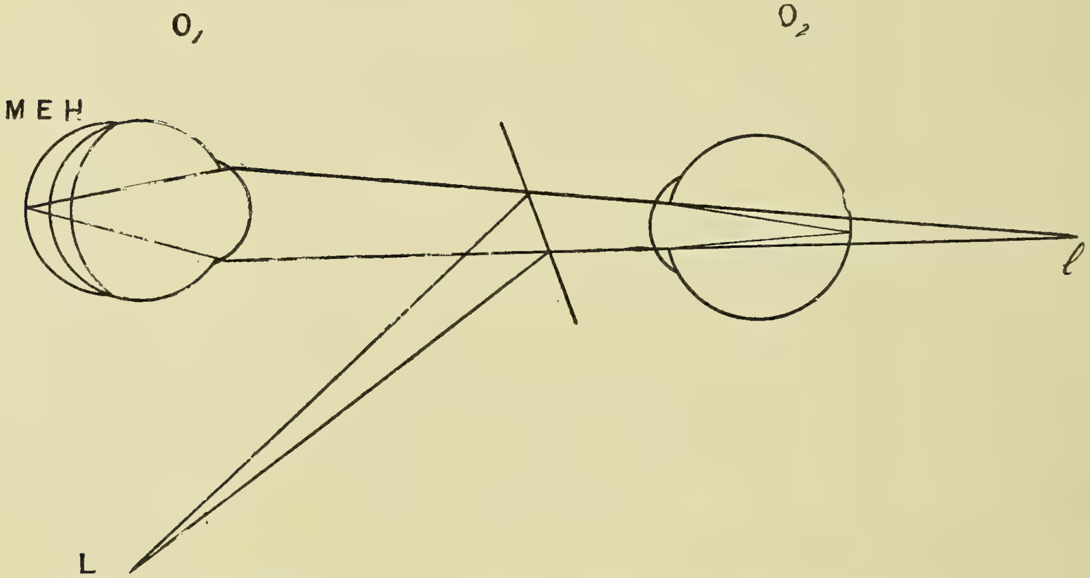

Fig. 72.—Diagram of von Helmholtz' ophthalmoscope. O_1, observed eye; O_2, observer's eye; L, source of light; *l*, image of L formed by the plane mirror—immediate source of light; M E H, relative positions of retina in myopia, emmetropia, and hypermetropia respectively, showing the relative sizes of the areas of retina illuminated in each case.

It will help us to understand the principles of the ophthalmoscope if we say a few words about its historical development. The original ophthalmoscope of von Helmholtz was merely a plane plate of glass (Fig. 72). A source of light was placed beside the observed eye and the glass plate obliquely in front of it, so that a portion of the light was reflected from the surface of the

(6) ¶

In recent years various self-luminous ophthalmoscopes have been devised. In most of these half the aperture of the ophthalmoscope is used for illuminating the fundus from a small electric bulb contained in the ~~[illegible]~~ instrument, the other half being used for observation. The ~~electric~~ lamp is run off a small dry battery, which can be placed in the handle of the ophthalmoscope. These instruments are particularly useful for bed-ridden patients.

plate into the eye. On looking through the transparent plate an observer could now receive some of the rays from the fundus into his own eye, and thus obtain an image of the illuminated fundus. Since but a small proportion of the light received upon the plate is reflected at its surface the illumination is feeble. Nevertheless, the principle is worth bearing in mind as a ready means of getting a view of a fundus in the absence of a more satisfactory ophthalmoscope. Moreover, an error of refraction in the observed eye may be obviated by using the corresponding spectacle glass of the patient as the ophthalmoscopic mirror.

Von Helmholtz next increased the amount of light reflected by superposing three plane plates. The back of the glass was next converted into a more powerful mirror by silvering it, leaving a small portion unsilvered or leaving a hole in the mirror, through which the observer might look. The illumination was still feeble, since the rays reflected by a plane mirror are divergent (*vide* p. 27). Ruete therefore (1852) introduced the perforated concave mirror which still holds the field. The final modification was the addition of a battery of small lenses of various strengths, which might be brought into position behind the aperture. The multitudinous forms of "refraction ophthalmoscopes" are merely various mechanical contrivances for doing this most conveniently.*

There are two chief methods of ophthalmoscopic examination, the direct method (v. Helmholtz, 1851) and the indirect method (Ruete, 1852). The ophthalmoscope is provided with two mirrors, one a small one, slightly tilted, for the direct method, the other a large one, not tilted, for the indirect method. Both are concave, the former with a focal distance of 30 cm., the latter of 10 cm. It is an advantage to have also two plane mirrors corresponding with these; with such a four-mirror ophthalmoscope the surgeon is fully equipped for every detail of ophthalmoscopy and retinoscopy.

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* The student is advised to procure a good ophthalmoscope at the outset of his clinical work in the medical wards. The cheaper forms are not only waste of money, but are a perpetual source of annoyance. The modification of Couper's ophthalmoscope, generally known as Morton's, is most strongly recommended.

The importance of system in his methods is so often impressed upon the student that he is liable to underrate it through sheer reiteration. It will perhaps suffice to say here that in using the ophthalmoscope he will inevitably come to grief unless he pursues his examination on a well ordered plan. The order of examination should be as follows:

(1) Preliminary examination with the mirror alone at a distance of about 1 metre from the patient;

(2) Examination with the mirror alone at a distance of about 20 cm. (reading distance) from the patient; this is sometimes called the distant direct method;

(3) Examination by the indirect method;

(4) Examination by the direct method.

The following facts will impress upon the student the reasonableness of this procedure. By (1) we obtain knowledge of the nature of the refraction of the eye under examination; this will prevent many little difficulties when we come to closer quarters. By (2) we see any gross changes, especially opacities in the refractive media; these may be made at once evident by this method, whereas they may be very puzzling if first observed by (3) or (4). In addition, we shall see the details of any very hypermetropic part of the fundus, such as a detached retina or glioma of the retina; these also are by no means difficult to miss by (3) and (4). By (3) we get a general view of the fundus—the largest

By tilting the mirror to & fro in various directions he can obtain an approximate idea of the refraction of the eye (v. p. 124) possible area under moderate magnification; it is exactly comparable to microscopic examination with a low power. By (4) we examine details under a higher magnification; it is exactly comparable to microscopic examination with a high power.

The student should commence by taking a patient whose pupils have been dilated with atropin, *e.g.*, a boy of twelve or fourteen who has come for the correction of his refraction. The atropin will have had the additional advantage of having paralysed the patient's accommodation. The observer should know his own refraction.

The patient is taken into the dark room and seated beside the light. The light is placed to the side which is to be examined, but well behind the level of the patient's face; the eye should be as much as possible in darkness. The observer sits facing the patient, about a metre from him. He reflects the light from the large ophthalmoscope mirror into the eye, meanwhile looking through the sight-hole. This requires a little practice, but is quickly mastered. When the light falls on the eye he notices a red reflex from the pupil. There ought to be no black spots in the pupillary area, but either a uniform red reflex or obscure details of the fundus.

The observer now stands up and approaches the patient until his eye, still with the large mirror, is about 9 inches from the eye under observation. He can now see the cornea and iris clearly, and can confirm any points which he has made out previously by the external examination.

He then sits down again at about a metre from the patient. Still keeping the light upon the eye with the large mirror, with his left hand he holds the large convex lens, which he will find in the ophthalmoscope case, close in front of the eye. He will be wise not to hold the lens absolutely vertical, but to tilt it a very little. He will probably see only the magnified iris through the lens. He now watches the red reflex from the pupil, and slowly withdraws the lens from the eye towards himself. At a certain point he will see an inverted image of the fundus quite clearly. The indirect method requires also some practice, but the amount required may be much diminished and much greater accuracy attained if the optical conditions under which the examination is made are thoroughly understood. These will be explained immediately.

Having obtained a good general view of the fundus, the observer again approaches the patient. He now uses the small tilted mirror of the ophthalmoscope. The mirror is tilted so that it faces towards the light. Looking through the sight-hole he first gets the light upon the eye ; this is best effected from a short distance away. When the light is well on the pupil and the observer can see the red reflex he approaches slowly nearer and nearer, watching that the light does not leave the pupil, until his brow is almost or quite touching the patient's brow. If now both the patient and the observer are emmetropic, the inexperienced observer will probably see the details of the fundus only indistinctly. He should then turn up with his index finger applied to the milled disc on the back of the ophthalmoscope successively stronger concave glasses (usually marked with white numerals). He will then probably see the fundus quite clearly. The image is erect, *i.e.*, the opposite of that by the indirect method. Here again practice is needed, and a knowledge of the optical conditions is quite essential.

We will now consider the chief features which are to be learnt in each stage of the examination, and how they are to be learnt.

I. Preliminary Examination with the Mirror at 1 metre.—We will suppose that the observer is emmetropic, or that his refraction has been corrected, and that the accommodation of the observed eye is at rest or paralysed. In examining the right eye the patient is told to look at the observer's right little finger which is held up; this is easily done whilst holding the ophthalmoscope. In examining the left eye the patient is told to look at the observer's left ear. In this manner the optic disc, which lies a little to the nasal side of the posterior pole of the eye, is brought into the observer's line of vision. When the optic disc is opposite the pupil we shall notice from a distance of 1 metre that the red reflex becomes much paler or even whitish.

If the eye is highly hypermetropic or myopic we shall see some details of the fundus, *e.g.*, a few vessels running across the reflex. The explanation is easy from what we have already learnt.

Consider first the hypermetropic eye. If we think of two spots on the retina, say at opposite edges of the disc, the rays reflected from these points will form two bundles of divergent rays when they leave the eye, just as if they came from the corresponding virtual remote points behind the eye (Fig. 73). The greater the distance from the eye, the greater will be the area over which these divergent rays will spread, so that at 1 metre some of the peripheral rays of each pencil will enter the observer's eye. By a slight effort of accommodation the observer will be able to bring these divergent rays to a focus on his retina, so that he will obtain a clear image of each point, and necessarily also of the intervening region. It is exactly as if the eye were taken away and the two points were situated at the remote points. Hence the image will be erect.

If the observer now shifts a little to one side, the observed eye remaining stationary, more rays will enter his eye from the neighbourhood of the opposite point, and less from the neighbourhood of the point on the same side as that to which his movement is directed. Although the points remain stationary, more of the fundus on the opposite side and less of the fundus on the same side will be seen. Hence the points will seem to move in the same direction as his own movement. The observer mentally regards the very sharp outline of the pupil as a fixed object of comparison, and as more of the fundus on the opposite side comes into view, whilst a corresponding amount on the same side disappears, this is mentally interpreted as a movement of the image in the same direction.

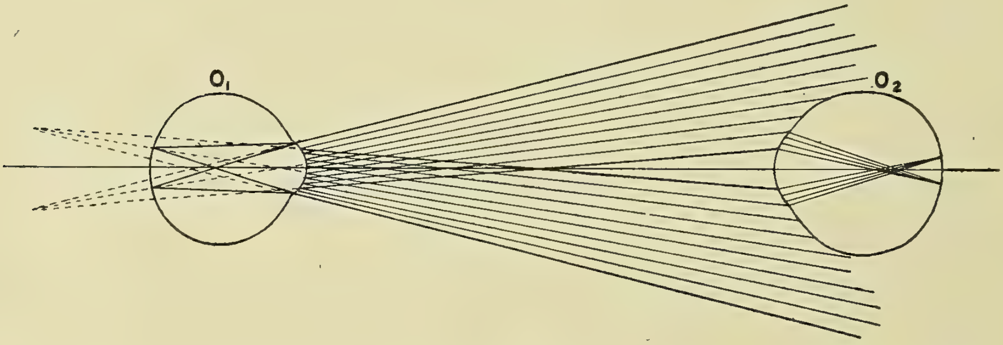

FIG. 73.—Examination with the mirror at 1 metre. O_1, observed eye, which is hypermetropic ; O_2, observer's eye, emmetropic, but accommodated for the divergent rays from O_1.

If, therefore, when the light is reflected into the eye at a metre distance we see vessels in the pupillary reflex, and if they appear to move in the same direction when the head is moved slightly to one side, we conclude that the eye is hypermetropic.

Consider now the myopic eye (Fig. 74). Here the emitted rays from the two points will be strongly convergent in each case, and a real inverted image of the points and intervening area will be formed at the remote

point of the eye, *i.e.*, between the observer and the observed eye. The rays will diverge from this image, and the effect will be exactly the same as if there were an actual inverted object in this position. If the myopia is sufficiently high, the image will be beyond the observer's near point, so that he will be able to accommodate for it. If he moves to one side he will see more of the observed fundus on the same side and correspondingly less on the opposite side, so that the fundus will appear to have moved in the opposite direction.

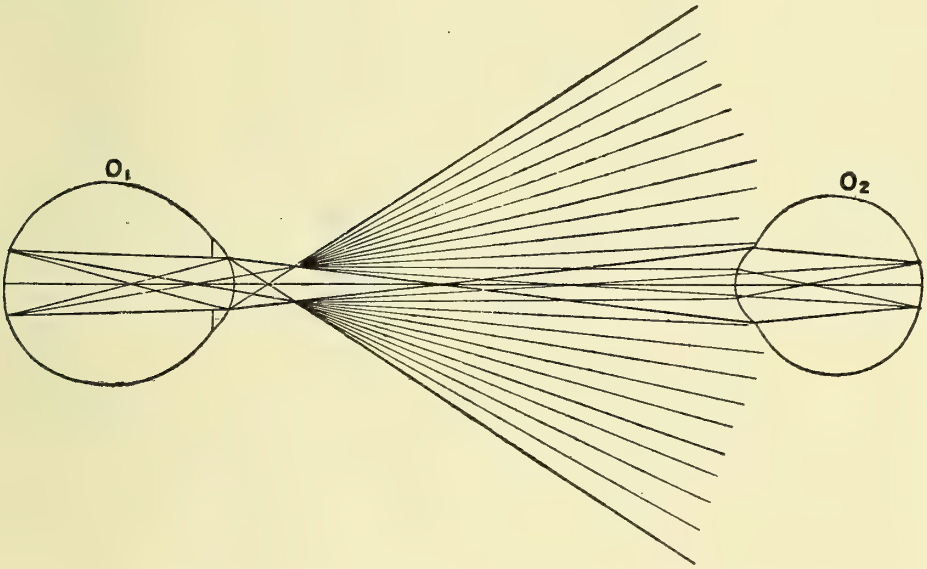

FIG. 74.—Examination with the mirror at 1 metre. O_1, observed eye, which is highly myopic ; O_2, observer's eye, emmetropic, but accommodated for the divergent rays from the far point of O_1.

If, therefore, when the light is reflected into the eye at a metre distance we see vessels in the pupillary reflex, and if they appear to move in the opposite direction when the head is moved slightly to one side, we conclude that the eye is myopic.

What will happen in emmetropia (Fig. 75) or low myopia, for the effect will be similar? Here the rays passing out of the eye from the two points will be parallel or very slightly convergent, and their direction will be that of their axes, which is the continuation of the lines joining the points with the nodal point of the eye. As these axes constantly diverge from one another, the observer at a distance of 1 metre cannot receive portions of both pencils of rays upon his own pupil, consequently he cannot obtain a clear image of the whole intermediate region between the spots. He may get a clear image from two spots very close together, but only if his accommodation is almost completely suspended, so that nearly parallel rays are brought to a focus upon his retina.

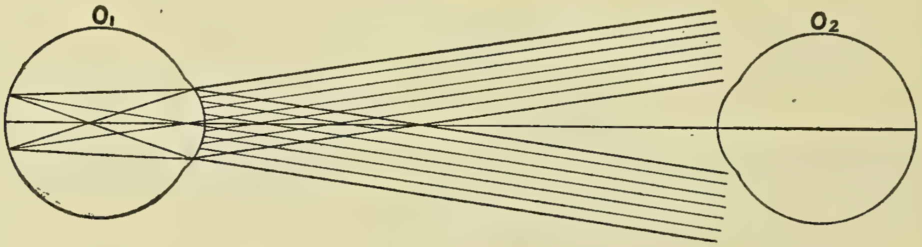

FIG. 75.—Examination with the mirror at 1 metre. O_1, observed eye, which is emmetropic; O_2, observer's eye: none of the rays from the widely distant points on the fundus of O_1 enter O_2. If the points are close together the rays of the two bundles will be nearly parallel, and would form a clear image on the retina of O_2 if the accommodation of O_2 were almost completely in abeyance.

The same reasoning applies to low hypermetropia, for here the remote point of the eye is so far behind the retina that the rays diverge very little when they leave the eye, so that they are almost parallel.

If, therefore, when the light is reflected into the eye at a distance of a metre we see only a red reflex in the pupil, without any details, we conclude that the eye is either emmetropic or has only a low degree of ametropia.

A still simpler means of discovering the condition of the refraction is as follows. Still throwing the light into the eye with the large concave mirror we tilt it gently in various directions. We shall see a shadow move across the pupil; if the shadow is very dark there is considerable

there is blood in the [illegible] /

& if it is sufficiently far forward in the [illegible] /

error of refraction. If it moves in the opposite direction to that in which we move the (concave) mirror the eye is hypermetropic; if in the same direction it is myopic. This method is used for correcting refraction, and we shall consider it in detail later (*see* Retinoscopy).

II. Preliminary Examination with the Mirror at the convenient distance for near vision (22 cm.).—At this distance the observer will be most suitably situated for distinct unaided vision, and he will be able to examine the superficial parts of the eye more accurately. If he is presbyopic he will naturally have to correct his presbyopia, and he may have to ~~do so~~ if he is strongly hypermetropic. If he is very myopic he will have to approach closer.

use a [illegible]

The advantages of a preliminary examination in this manner are (1) the recognition of opacities in the refractive media; (2) the recognition of a detached retina or other substance not far behind the lens; (3) the confirmation of the results found by the external examination.

(1) *The diagnosis of opacities in the refractive media.*—If the eye is normal there will be a red reflex from the pupil. If there is any opaque body in the course of the rays reflected from the fundus it will stop these rays and will therefore appear black. The whole field may be black, as when the lens is entirely opaque, or when ~~the vitreous is filled with blood~~. In the latter case oblique illumination will show the red blood behind the transparent lens: the blood looks red in this case because of the light reflected from its surface.

Opacities vary in shape, size, and position. We are particularly concerned to discover their position, as this frequently gives the key to their nature.

The first point to determine is whether the opacity is movable. This is done by telling the patient to move his eye in different directions—towards the ceiling, towards the floor, to the right, to the left—and then to look straight forward. A floating opacity will then continue to move after the eye is brought to rest. It must therefore be either in the aqueous or vitreous. In the former position it can be seen and diagnosed by other methods. If it is in the vitreous and is freely movable we also learn that the vitreous is fluid, which is not its normal consistency. If the opacity moves only with the eye it may be in the cornea, lens, or vitreous, which, under these circumstances, will have its usual viscous consistency.

The next point is to determine its exact position. This is effected in the preliminary examination with the mirror alone by *parallactic displacement.*

In Fig. 76, if 4 is the centre of rotation of the eye, and if there are opacities at 1, 2, 3, 4, 5, then, when the eye is rotated a small amount, the opacities, 1, 2 and 3, in front of the centre of rotation will move in the direction of rotation, and 5, behind the centre, will move in the opposite direction, whilst 4, at the centre, will not move. It is obvious that the amount of movement will be greater the farther the opacity is from the centre of rotation. Now, we have no means of defining the centre of rotation by ophthalmoscopic examination, but all the movements will be referred to the edge of the pupil for comparison (*vide* p. 122). If the observer is situated at A, all the opacities will appear as a single spot in the centre of the pupillary reflex. If he shifts his position to B, or if the eye is rotated a corresponding amount in the opposite direction, the opacity 2 will remain in the centre of the pupil, whilst 1 will move towards one edge of the pupil, and 3, 4 and 5 towards the opposite edge, 5 being lost entirely behind the iris.

Hence we deduce the rule that if the eye is moved slightly in a given direction, opacities in the pupillary

plane will appear stationary; those in front of that plane will move in the same direction, and those behind will appear to move in the opposite direction, the amplitude of apparent movement being a rough indication of their distance from the pupillary plane.

There is another guide which we may make use of, viz., the corneal reflex. This is the image of the mirror formed by the cornea. With the ordinary concave mirror it is a virtual image (*vide* p. 29) situated about 4 mm. behind the anterior surface, *i.e.*, a short distance behind the anterior surface of the lens (behind 2 in Fig. 76). The centre of curvature of the cornea is situated 8 mm. behind its anterior surface, *i.e.*, less than 1 mm. behind 3 (Fig. 76). The corneal reflex will always cover this latter spot, the centre of curvature of the cornea, no matter what the position of the eye. Hence an opacity situated here will always be covered by the corneal reflex; opacities in front of the centre of curvature move in the same sense with regard to the reflex as the eye moves; and opacities behind it move in the opposite direction to the movement of the eye. Therefore, in Fig. 76, in the first position of the eye, the opacities 1, 2, 3, 4, 5, will all appear in the

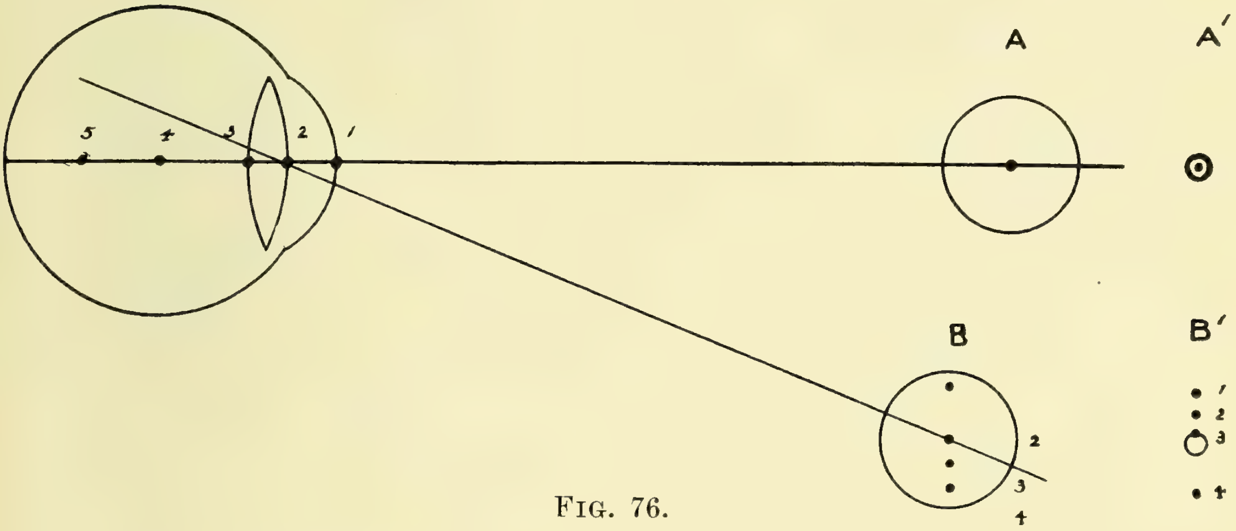

FIG. 76.

centre of the corneal reflex (A′); in the second position they will appear as in B′; so that an opacity at the posterior pole of the lens will scarcely leave the edge of the reflex, whereas an anterior polar opacity will move much farther from it.

One peculiar apparent opacity is seen by the mirror alone, and this method affords the surest means of discovering the defect. This is the edge of a dislocated lens, or the notch in the edge of the lens in congenital coloboma of the lens. When the edge of the lens crosses the pupillary area it is seen as an intensely black crescent, sharply defined peripherally but merging centrally into the clear red reflex. The reason of this appearance is that the whole of the light which falls upon the extreme edge of the lens is totally reflected; none of it leaves the eye, so that none can enter the observer's eye.

We not infrequently meet with very fine opacities, especially in the vitreous. If we use a concave mirror and a bright light we shall probably fail to see them, the reason being that these very delicate opacities are partially transparent, so that if the light is very bright some passes through them and contrast is reduced. Contrast is further reduced by reflection of light from their surfaces. They are, as it were, drowned in light. In order that we may be sure of not missing fine opacities the best method to adopt is to use a plane mirror. The rays reflected from a plane mirror are divergent (*vide* p. 27); hence less light enters the eye. If we have no plane mirror available the light should be reduced, but this is not so satisfactory. We may increase our chances of seeing the specks if we place a convex lens behind the mirror, which will have the effect of magnifying them (Fig. 21).

(2) *The recognition of detached retina, &c.*—A detached retina is situated much in front of its normal position;

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it is therefore in the position of the fundus of a very hypermetropic eye. When light is thrown in from a mirror at reading distance light will probably be reflected from the surface in such a way that some rays will enter the observer's eye. A difference of reflex in different directions is noticed, red in some, grey or black in others. More minute investigation will reveal a whitish or greyish uneven surface upon which there are almost black wavy lines; these are the retinal vessels. Particular stress is laid upon this point, because the appearances of a detached retina by the indirect and direct methods may be very puzzling to the beginner. If the precaution is always taken of using the mirror alone ~~first~~ little difficulty is likely to arise.

Besides a detached retina we shall also be able to see anything else in a similar position, *e.g.*, a tumour pushing the retina forwards, or a tumour of the retina itself (glioma), and so on.

None of these will be seen unless they are pushed forwards very considerably; hence we must not asseverate the absence of a detached retina, &c., if we fail to see it by this method.

(3) *Confirmation of the results found by the external examination.*—We are able by this method not only to confirm the results previously arrived at by external examination, but also to supplement them by important subsidiary information. Thus we are able to map out the limits of opacities in the lens much more accurately, since they now appear black on a red background, and as has already been shown we can determine their exact position with much greater precision.

We may have noticed a black spot in the iris in a case with the history of a foreign body having gone into the eye. It is probable that the foreign body has passed through the iris, and that the black spot is a hole. The examination with the mirror often at once settles the question, for if there is a hole we shall be able to find some position in which a red reflex can be seen through the hole. The absence of a red reflex does not prove the absence of a hole, for the lens may be opaque behind the hole.

The following is a somewhat similar example. We have noticed a black patch at the ciliary margin of the iris, convex in outline towards the pupillary margin. It may be a melanotic sarcoma of the ciliary body growing forwards and implicating the iris: or it may be a separation of the iris from its ciliary attachment (iridodialysis). In the latter case it will be possible to obtain a reflex through it by the mirror, whereas in the former it will be opaque.

We have said that by this method opacities in the refractive media appear black. Superficial opacities, however, such as those in the cornea and near the anterior surface of the lens, can be seen in their natural colours by approaching still nearer to the eye. Under these conditions more light is reflected from the surface of the opacities and some of it enters the observer's eye. It will be objected rightly that now we shall be within our near distance and consequently shall not be able to see anything clearly. This is true, but it can be obviated by assisting our accommodation by putting up gradually stronger convex glasses behind the ophthalmoscope mirror as we approach the eye. This has the additional advantage of magnifying the opacity. If we approach very close to the eye and place a + 20 D lens behind the mirror we shall see the opacities highly magnified. This glass will be acting very much like an ordinary magnifying glass, so we shall have to focus it in much the same manner. We therefore start a little distance from

the cornea and watch carefully as we get nearer and nearer; there will come a point when the opacity is very clearly defined.

Suppose now that under the same circumstances, with the + 20 D lens in the position for seeing the cornea, we wish to examine an opacity near the surface of the lens it can be done in two ways. We may continue to approach still nearer until it comes into focus; or we can use a weaker lens, retaining our original position.

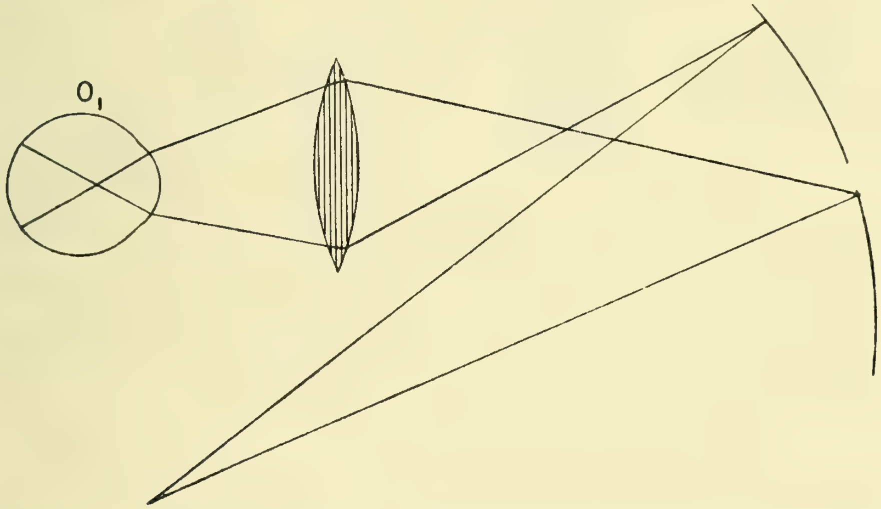


FIG. 77.—Indirect method. Illumination of the fundus, showing the course of rays from the source of light to the mirror, through the lens, and through the eye; also the area of the field of illumination.

The weaker lens is most easily produced by moving up stronger and stronger concave lenses in front of the + 20, until the opacity is accurately focused. This is made possible in most ophthalmoscopes by having a + 20 D lens set in a disc which lies behind the sight-hole: the lens can be turned into position when required, and does not interfere with the use of the other lenses at the same time. The opacity in the lens will of course not be quite so highly magnified by the second as by the first method.

III. **The Indirect Method.**—The indirect method of examination with the ophthalmoscope consists essentially in making the eye, whatever be its refraction, highly myopic by placing a strong convex lens in front of it (Figs. 77—79). The effect of this will be to form a real inverted image of the fundus between the observer and the convex lens, as will be easily understood from the accompanying diagrams. If the eye is already myopic the convergent rays which come from any point on its fundus will be made still more convergent by the lens, and the inverted image which is always formed in myopia will be brought close to the lens. If the eye is emmetropic the parallel rays emitted will be made strongly convergent, and where they cross the inverted image will be formed. If the eye is hypermetropic the rays will still be made convergent, for the lens used is so strong that the divergence in hypermetropia is never strong enough to prevent it.

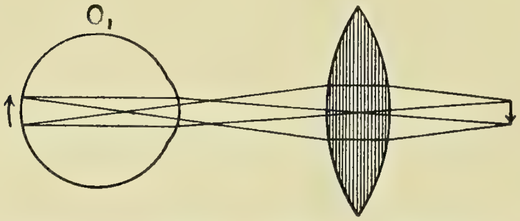


FIG. 78.—Indirect method. Emergent rays from the fundus, showing the formation of the image. In the figure the lens is situated at the anterior focal plane of the eye; the rays which are parallel inside the eye, therefore, pass through the optical centre of the lens. The rays which pass through the nodal point of the eye are rendered convergent by the lens. The points where these two systems of rays cross gives the position of the image, which is seen to be inverted.

It will be seen that with the same lens the inverted image is formed at different distances beyond it according to the refraction of the eye. If the lens is kept at a constant distance from the eye, *e.g.*, its own focal distance, the emmetropic image will be formed at the focal distance of the lens beyond it: the myopic will be nearer to the lens, the hypermetropic farther from it (Fig. 79).

In all cases the image is magnified, the amount of

magnification depending upon the refraction of the eye, the strength of the lens, and its distance from the eye. With a + 13 D the fundus of an emmetropic eye is magnified about five times.

One of the greatest difficulties in using the indirect method is the group of reflexes formed by the eye and the surfaces of the lens. We have seen that the cornea forms a reflex of the mirror when it is used alone. This reflex, when seen through the convex lens, is magnified, so that it may cover the pupil and prevent anything behind being seen. But the surface of the lens towards the observer acts like another convex mirror, and forms another reflex situated behind the lens. Similarly the surface of the lens near the patient acts like a concave mirror and forms a reflex on the observer's side of the lens. These reflexes are very troublesome, but they may be got out of the way by a little manœuvring. It has been said that the two lens reflexes, which are the most troublesome, are images of the mirror formed on opposite sides of the lens. If we tilt the lens a little it will be found that these reflexes move in opposite directions, and we can look quite comfortably between

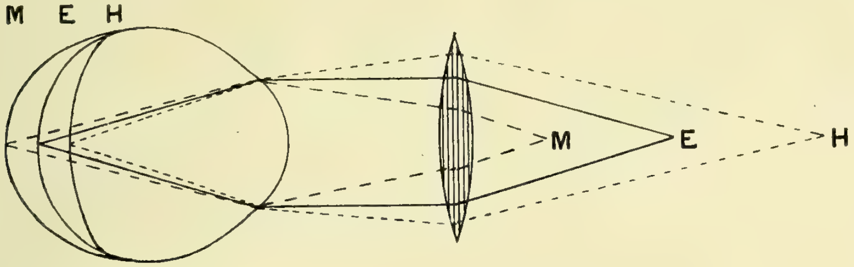


FIG. 79.—Indirect method. Position of the image according to the refraction of the eye. In this figure the lens is situated at its own focal distance from the cornea. In emmetropia the parallel emergent rays, therefore, cross at the principal focus of the lens, E. In myopia the convergent emergent rays cross nearer to the lens than its principal focus, viz., at M; in hypermetropia the divergent emergent rays cross farther from the lens than its principal focus, viz., at H.

them. We must be careful not to tilt the lens more than is necessary, because if we look obliquely through a tilted lens objects appear distorted: in fact we produce one type of astigmatism. The distorted image of the disc produced in this manner may be attributed to astigmatism in the eye, when none is really present.

Another difficulty which the beginner usually experiences is due to ~~him~~ getting too close to the patient. If he understands the position of the image which he is looking for, as described above, he will discover why he can see no sharp image when he is too close to the patient. Most people using the indirect method think that they are looking at the pupil. As a matter of fact, when the fundus is seen clearly, they are not accommodating for the pupil, but for the real image of the fundus, which is in the air somewhere between the lens and the observer. Now we can only see an object clearly with the unaided eye if it is at a convenient distance away. Consequently, if the observer gets so close to the patient that he is less than the distance of his near point from the aerial image he cannot see it clearly.

If we like to do so we can get over this difficulty and still remain closer to the patient. In order to do so, the observer must help his accommodation by putting up a convex lens in front of his eye. If we put up a + 1 D or + 2 D behind the ophthalmoscope mirror, we shall not only see the image clearly at a shorter range, but we shall also magnify it, an additional advantage.

As regards the position of the convex lens before the patient's eye, there is a considerable range over which we can see the fundus quite well, but some positions are better than others. In practice we find the best position by putting the lens close to the eye to start with, steadying it by the little finger applied to the patient's

brow, and gradually bringing it farther away from the eye until the best position is obtained.

Theoretically, from the point of view of the maximum field of fundus seen, the best place for the lens is its own focal distance from the patient's pupil. But this is the very worst place from the point of view of the corneal reflex. The latter is situated at about the level of the iris (4 mm. behind the cornea, *vide* p. 127). If the convex lens is at its focal distance from it, the rays from this image will be made parallel by the lens, *i.e.*, the reflex will fill the whole area of the lens, and we shall see nothing else. Hence the best position for practical purposes is either nearer to or farther from the eye than this position. We shall see later that a convenient distance is when the lens is at its focal distance from the anterior focus of the eye. Here, slight tilting of the lens, besides shifting the lens reflexes out of the way, will also move the corneal reflex and the image of the fundus in opposite directions, and so get the corneal reflex out of the way.

We can tell by the indirect method whether the eye is emmetropic or ametropic by observing the effect of shifting the lens on the size of the image of the fundus. We use the disc as the best guide, getting it into the field by telling the patient to look in the appropriate direction, *i.e.*, towards the raised right little finger when examining the right eye, towards the left ear when examining the left.

Place the lens close to the eye and gradually bring it farther away. If the image of the disc does not alter in size the eye is emmetropic; if it gets smaller the eye is hypermetropic; if it gets larger the eye is myopic.

If we understand why this is so, we shall be able to remember what happens in each case. Imagine two points, *a* and *b*, upon the fundus, *e.g.*, upon opposite edges of the disc (Fig. 80). If they are illuminated, one of the many divergent rays emitted by each must be parallel to the axis. These two rays, when they pass out of the eye, will cross at the anterior focus of the eye, whatever its refraction may be, as long as the error is one of undue length or shortness (*axial ametropia*). They will cross at the anterior focus because they are parallel to each other before refraction. Now, suppose that the convex lens used in the indirect method is situated at its focal distance from the anterior focus of the eye. These two rays, after they have crossed, will meet the convex lens, and since they come from the focus of the lens they will be parallel to each other after refraction. As we have already seen (p. 133), under such circumstances the image of the fundus is formed in emmetropia at the focal distance of the convex lens (F^1) from it (E): in myopia the image will be nearer the lens (M), in hypermetropia farther away (H). The two rays which we have been considering must represent the images of the two points on the fundus. Hence the distance between them after refraction by the eye and by the lens will give the size of the image of the portion of fundus between *a* and *b*. We see therefore that when the lens is at its own focal distance from the anterior focus of the eye the magnification of the image is the same in emmetropia, in axial myopia, and in axial hypermetropia.

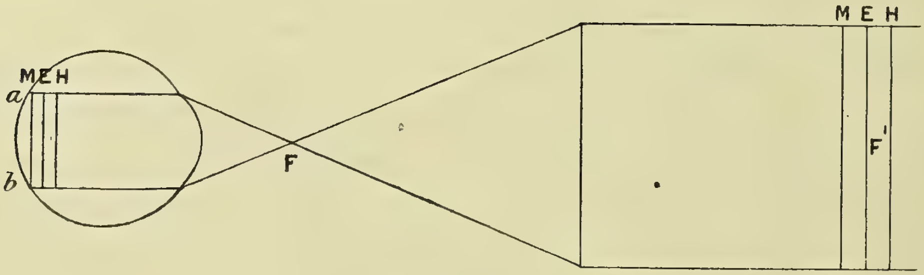


FIG. 80.

If the lens is nearer the eye than the above distance (Fig. 81) the rays under consideration will diverge after refraction by the convex lens. Hence, if the lens is less than its own focal distance from the anterior focus of the eye, the magnification is greatest in axial hypermetropia, least in axial myopia, and intermediate in emmetropia. Conversely, if the lens is farther from the eye, the rays under consideration will be convergent after refraction by it. Hence, if the lens is more than its own focal distance from the anterior focus of the eye, the magnification will be greatest in axial myopia, least in axial hypermetropia, and intermediate in emmetropia.

In *curvature ametropia*, such as we meet with in astigmatism, the results are not quite the same, but they are easily deduced if we remember that there are now two anterior foci to the eye, one for each meridian. There are also two nodal points. When the lens is at its focal distance from the cornea the magnification is the same in emmetropia and any ametropia of curvature. Under these circumstances the disc appears circular. If the lens is nearer the eye the image is elliptical, with its long axis in the less refractive meridian, *i.e.*, generally horizontal. If the lens is farther from the eye the long axis is in the more refractive meridian, *i.e.*, generally vertical. As mentioned before, it is essential that the lens should be held almost vertical, as any inclination makes it itself astigmatic.

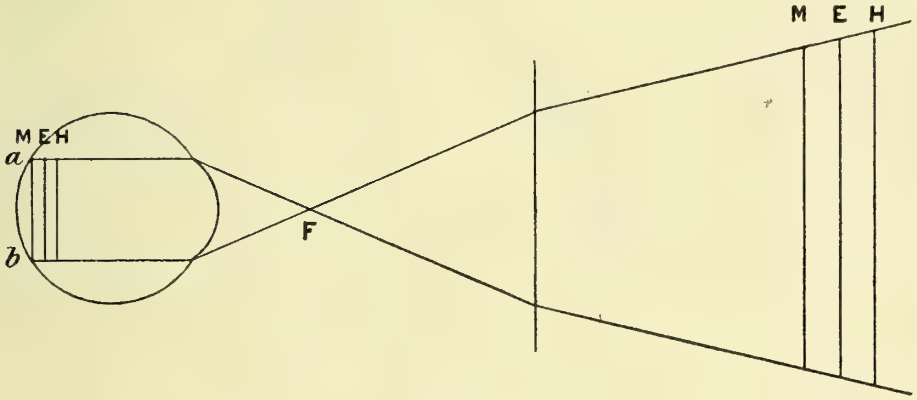


FIG. 81.

If the disc is really oval, as in high myopia, the axis of the ellipse will of course remain unaltered.

Ametropia of index of refraction occurs in old age. Aphakia, the condition when the lens has been removed, may be considered an extreme form of index ametropia. Here the position of the nodal point remains invariable, and if the convex lens is at its focal distance from this point the image is the same size in emmetropia and ametropia of index of refraction. If the lens is moved closer to the eye the image increases in hypermetropia and diminishes in myopia, whilst it remains the same in emmetropia. Since the image is formed at a considerable distance beyond the focus of the lens in the high hypermetropia of aphakia it is convenient to use a stronger lens, *e.g.*, +18 D.

Differences of level of two points near each other on the fundus are made very evident by parallactic displacement in the indirect method. Thus, in Fig. 82, if there are two spots, *a* and *b*, at different levels in the fundus, *e.g.*, on the edge of the disc and at the bottom of a glaucoma cup, when the lens is shifted slightly so that its optical centre moves from o_1 to o_2, the images of *a* and *b* will move from a_1 to a_2, and b_1 to b_2. It is of historical interest that this displacement was at one time wrongly interpreted, so that a glaucomatous cupping of the disc was diagnosed as a swelling.

IV. The Direct Method.—In the direct method the observer approaches as close as possible to the patient's eye (Fig. 83). If the eye is hypermetropic the emergent rays will be divergent, as if coming from the virtual remote point behind the eye. Owing to the short distance between the eyes a large pencil will fall upon the observer's pupil, and may be brought to a focus upon his retina if he makes a suitable effort of accommodation. If he is presbyopic, or if his accommodation is relaxed, he will only obtain a clear image by placing a convex lens behind the sight-hole of the mirror (Fig. 84, H).

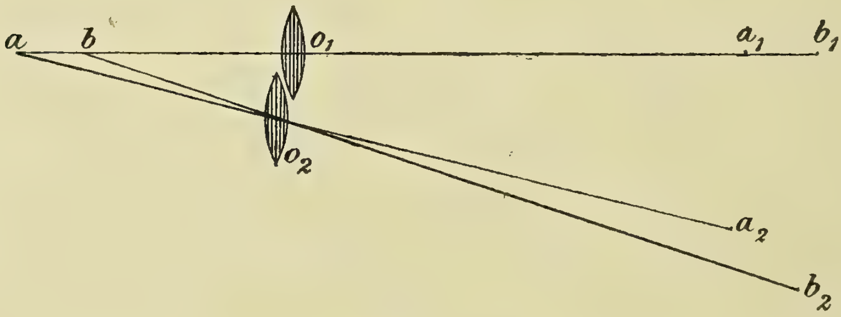


FIG. 82.—Indirect method. Parallactic displacement.

If the observed eye is emmetropic the emergent rays will be parallel, and consequently can only form a clear image upon the observer's retina if his accommodation is absolutely relaxed (Fig. 84, E)—unless, indeed, he

counteracts the amount of his accommodation by a corresponding concave lens in front of his eye (*vide* p. 140).

If the observed eye is myopic the emitted rays are convergent. If the myopia is moderate the real image of the fundus at the far point of the eye will be behind the observer's head, *i.e.*, he will catch the convergent rays before they have come to a focus. These convergent rays, entering his emmetropic eye, are brought to a focus in his vitreous; hence he cannot possibly obtain a clear image unless he counteracts the convergence by an equivalent concave lens behind the mirror (Fig. 84, M) If the observed eye is very highly myopic its punctum remotum will be situated somewhere in the space between the eye itself and the observer's retina, and it may be in such a position that it is impossible to obtain a clear image with any correction. For example, the remote point may be just behind the sight-hole of the mirror. Here it is too close to be accommodated for, and no correcting glass situated at the same position will have any effect upon the rays, for they will nearly all pass through the

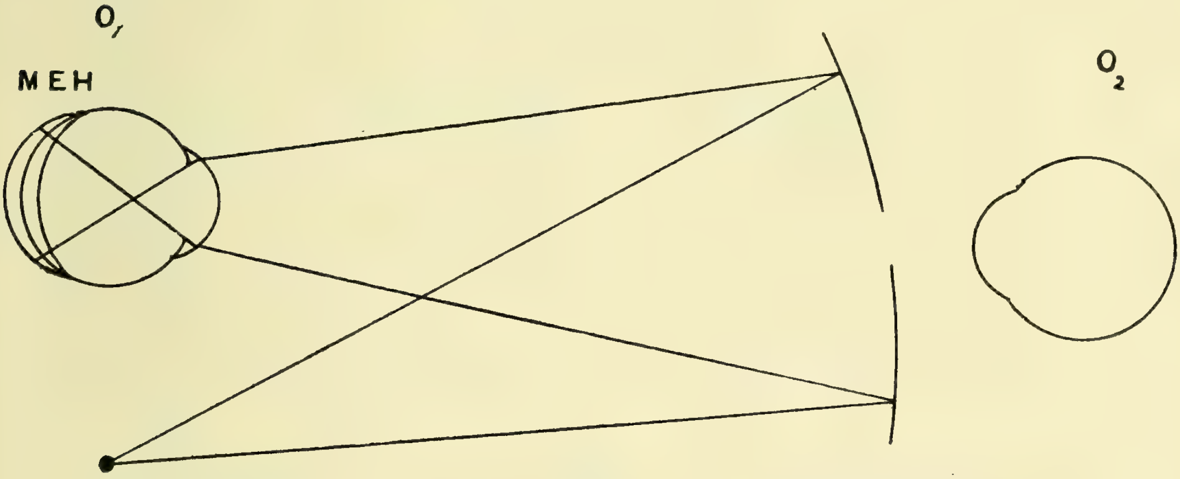


FIG. 83.—Direct method. Illumination of the fundus, showing the course of rays from the source of light to the mirror and through the eye; also the area of the field of illumination. Compare with Fig. 77.

optical centre of the lens. The practical outcome of this discussion is to get as close to the eye as possible.

Much stress is generally laid upon the necessity and the difficulty of relaxing one's accommodation in examination by the direct method. It is difficult to relax the accommodation entirely when the eye is apparently close to the object looked at. The observer should try to think that he is looking at a very distant object, but even then, as soon as he directs his attention to details of the picture, he is almost certain to accommodate. It is best for the beginner not to worry himself about this point: if he cannot see an emmetropic fundus clearly let him put up

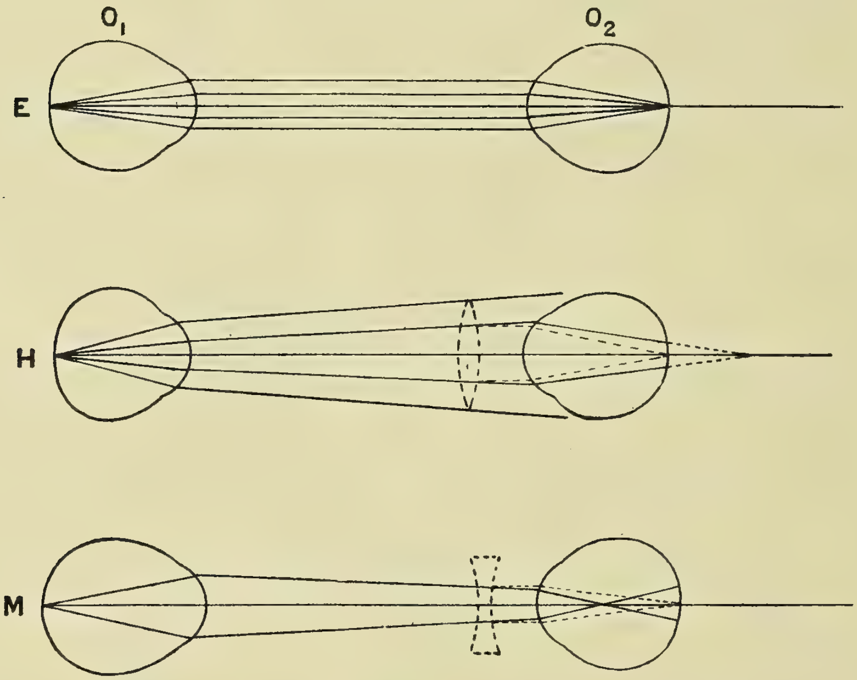


Fig. 84.—Direct method. Emergent rays from the fundus of the observed eye, O_1, showing the formation of the retinal image on the retina of the observer's eye, O_2. In emmetropia, E, the emergent parallel rays are brought to a focus on the retina of O_2 if the accommodation of this eye is absolutely at rest. In hypermetropia, H, the emergent divergent rays are brought to a focus on the retina of O_2, either by means of accommodation or by placing a convex lens in front of O_2. In myopia, M, the emergent convergent rays can only be brought to a focus on the retina of O_2 by placing a concave lens in front of O_2.

minus lenses until he does. After he has acquired facility in seeing anything at all it will be soon enough for him to grapple with this difficulty.

The image by the direct method is always erect. Thus, in hypermetropia it is exactly as if the observer were looking at an actual object situated at the remote point of the eye, *i.e.*, some distance behind the eye. In myopia the converging rays are caught before they cross; they are made suitably less convergent by the correcting lens behind the mirror, so that again an erect image is seen. In emmetropia the emergent rays are parallel and are, therefore, also caught before they cross—at infinity; hence, again, an erect image is seen.

The image is always magnified, and it is magnified more than by the indirect method. In emmetropia the fundus is seen magnified about fifteen times. In hypermetropia it is magnified less, and in myopia more than in emmetropia.

The field of ophthalmoscopic vision by the direct method, *i.e.*, the area of the fundus which can be seen, varies with the distance of the observer from the eye and with the refraction of the eye. It increases as the eye is approached—another reason for getting as close to the eye as possible. It is greatest in hypermetropia, least in myopia, and intermediate in emmetropia. Thus, we see the largest area, least magnified, in hypermetropia, and we see the least area, most magnified, in myopia.

In astigmatism the magnification is greatest in the more myopic meridian, and least in the more hypermetropic. In the usual form of astigmatism the image of the disc is an ellipse with the long axis vertical—the opposite of the usual image by the indirect method, with the lens near the eye (*vide* p. 137). It is obvious that there can be no clear image of the whole field by the direct method in astigmatism. *Only lines perpendicular* *to the meridian which is corrected are seen clearly.* Lines in any meridian other than the two principal ones cannot be seen clearly by any spherical correcting glass, but only by a cylindrical lens or combination of a spherical and a cylindrical.

From what has been said it is obvious that the correcting lens behind the sight-hole of the mirror also represents the spectacle glass which will be required to correct the refraction if it is placed in the same position. This, of course, is only true if the observer is emmetropic, or has his refraction corrected, and if his accommodation is quite at rest. Since it is difficult to relax the accommodation completely, this method of determining any error of refraction should only be used as a rough estimate, unless the observer is an expert. Some surgeons attain great skill in measuring the refraction by the direct method. They can even correct astigmatism. In this case they correct one meridian first, which gives the lens correcting the meridian at right angles to it; the process is then repeated in the other meridian.

If there is a difference in level between two points on the fundus, *e.g.*, the edge of the disc and the bottom of a glaucoma cup, it is made manifest by the direct method also by parallactic displacement. If we focus the edge of the disc and then move slightly to one side the edge of the disc will appear to move over the bottom of the cup, *i.e.*, it moves in the opposite direction. An object farther forward, therefore, moves in the opposite direction to the movement of the observer's head.

The difference in level can be accurately measured. In the example given, the bottom of the disc will be relatively myopic to the edge, since it is farther away from the back of the lens. If the eye is emmetropic and the edge of the disc can be seen clearly without the assistance of any correcting lens we shall require a concave

lens to see the vessels at the bottom of the cup clearly. It can be proved that if the correcting lens is at the anterior focus of the eye a difference of 3 D is equivalent to 1 mm. difference of level. We must get as close as possible to the eye when measuring differences of level, because only then are the conditions of accuracy fulfilled. If, with the observer's accommodation at rest, he sees the edge of the disc clearly with no correcting lens, but requires – 3 D to see the bottom clearly, he knows that the bottom is 1 mm. behind the edge. He will of course see the bottom clearly with a higher concave lens if he counteracts the excess by accommodating: hence he must be careful to choose the lowest minus lens.

Similarly projections forwards can be measured. Here the observer chooses the highest convex lens with which he can see some well-defined point on the top of the eminence. The same rule that 3 D is equivalent to 1 mm. holds good. Suppose, for example, that he is measuring the swelling of the disc in a case of optic neuritis. He first finds the highest convex glass with which he can see clearly a retinal vessel a little distance away from the disc. He then finds the highest convex glass with which he can see a vessel or a small hæmorrhage as near the top of the swollen disc as he can judge. The difference between the two lenses will give the height of the swelling.

It will be seen that the difficulty of relaxing the accommodation enters into this estimation. The student need not, however, be dismayed. Very fairly accurate results can be obtained without relaxing the accommodation, for if he is accommodating the same amount when he measures the top of the swelling that he is when he measures the level of the surrounding fundus the difference between the two observations will be the same as if he was not accommodating at all. He can ensure this fairly well by always choosing the highest convex lens ; it is safest to choose the lens which just makes the object looked at appear a little blurred. Of course the eye may be myopic; if for "convex lens" in the above description "relatively convex lens" be substituted— − 1 D being relatively convex to − 4 D—the principle is the same.

An object in the vitreous, *e.g.*, a large opacity, is in the same condition as the fundus of a hypermetropic eye. If the eye is emmetropic, so that the fundus is visible without any correcting lens, the opacity can be examined either by accommodating for it or by putting up convex lenses until it is clearly focused. If it is close behind the lens accommodation will have to be assisted by a convex lens in any case, unless the observer withdraws farther from the eye. It will be seen, therefore, that by putting up convex lenses from 0 to + 20 D we can thoroughly explore the emmetropic eye from the fundus to the surface of the cornea.

Examined in this manner the appearance of opacities in the vitreous or lens will vary with the amount of light stopped by them, *i.e.*, by their density, and with the amount of light reflected from their surfaces. If they are very dense they will appear black against the background of the red reflex. If they are semi-transparent they will appear red or whitish according to the relative amounts of light transmitted from the fundus and reflected from the surface. A detached retina may therefore look red or white, according to its degree of transparence. If much light is reflected from the surface details may be seen upon it; otherwise it appears uniformly black.

CHAPTER VIII.

THE FUNDUS OCULI.

When the fundus is observed by the indirect method it is seen to be of a bright red colour. This is due chiefly to the blood circulating in the choroid. In people of dark complexion no choroidal blood vessels are seen on account of the retinal pigment epithelium, which, whilst dense enough to blur any details, is not sufficiently dense to prevent the colour of the blood manifesting itself.

The Optic Disc.—The first object to be sought is the optic disc or papilla (Plate III., Fig. 1). As already mentioned, it is done by making the patient look slightly towards the nasal side. The reflex then suddenly changes from bright red to white, and if the optical conditions are properly arranged in accordance with the directions given in the last chapter the disc will be clearly seen.

The disc is pale pink in colour, the tint showing considerable variations within the limits of normality. It is nearly circular, but seldom perfectly so; it is about 1·5 mm. in diameter, but of course is seen magnified. The oval appearance due to astigmatism must be borne in mind (*vide* p. 141). The edges are usually quite sharp, but sometimes a little irregular. Not uncommonly, especially in old people, there is a narrow white ring around the pink disc, *the scleral ring;* this is due to the choroid and the pigment epithelium of the retina not extending quite up to the margin of the disc so that the sclerotic is seen through the retina. Sometimes there is a ring of black pigment around the margin of the disc, due to the retinal pigment epithelium being heaped up here. More commonly parts of the circumference have black patches, but they are not continuous. These features are of no importance from the pathological point of view.

The disc itself is seldom uniformly pink. The central part is usually paler and may be quite white, and this lighter area may extend nearly to the temporal edge of the disc; it rarely extends quite to the edge. The temporal side is therefore normally paler than the nasal. The central vessels emerge from the middle of this white area, and careful examination with the direct method will show that the area is a funnel-shaped depression, *the physiological cup*. This cup varies very much in different eyes. When it is very deep the central part may be seen to be speckled with grey spots; these are the meshes of the lamina cribrosa through which the nerve fibres are passing. Sometimes there is scarcely any physiological cup; the disc is then more uniformly pink, and the central vessels may have already divided before they come to the surface. The true nature of the physiological cup is best understood by comparing the ophthalmoscopic picture with a microscopic section vertically through the nerve head.

The colour of the disc is due to the white fibres of the lamina cribrosa seen through the vascularised nerve fibres. Where the nerve fibres are thinnest, *i.e.*, in the cup, the white lamina shines through brightest. The grey spots in the lamina, when they are seen, are due to the non-medullated nerve fibres reflecting less light than the white connective tissue fibres.

The Retinal Vessels.—The retinal vessels are derived from the central artery and vein, which usually divide into two branches at or near the surface of the disc. These branches are above and below, and form a superior and an inferior trunk (Plate I.). Each trunk usually divides into

PLATE III.

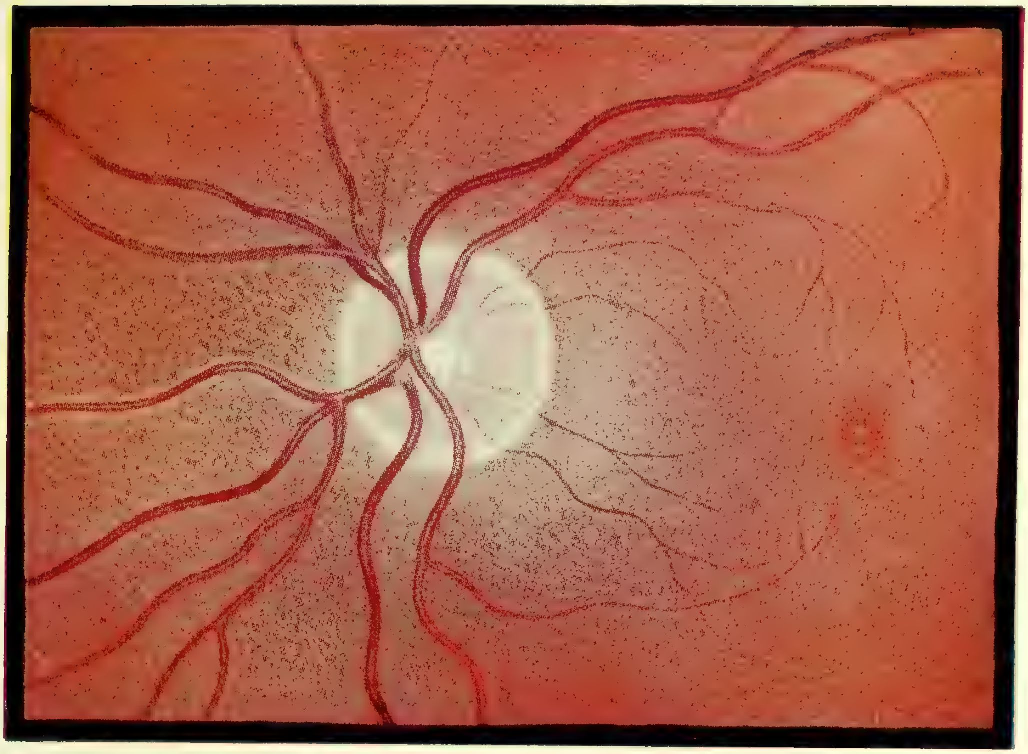


FIG. 1.

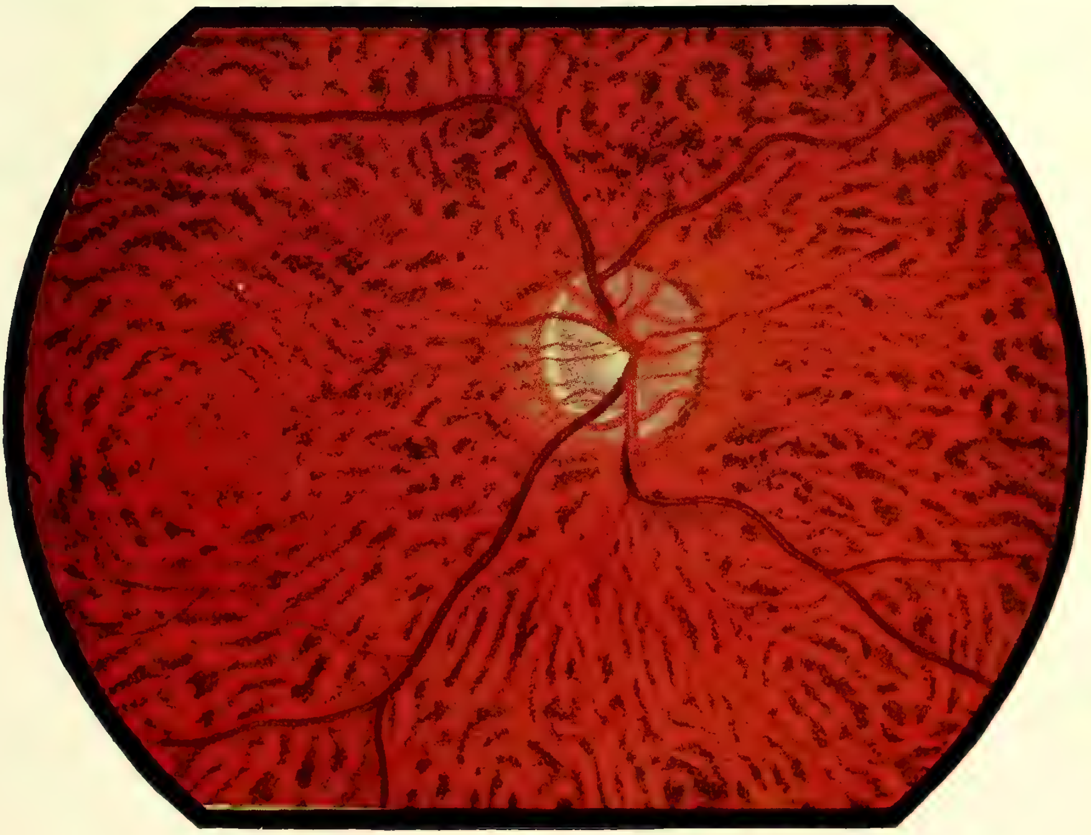


FIG. 2.

two, one of which sweeps up or down towards the temporal side, the other sweeping up or down towards the nasal side. These branches are called the superior and inferior temporal and nasal arteries and veins. They divide dichotomously into innumerable branches.

The arteries are distinguished from the veins in being lighter red and narrower. The veins have a purplish tint and are often more convoluted; less frequently the arteries are tortuous. What is ~~actually~~ seen is the blood column, not the actual vessel wall, which is transparent. Each, but especially the arteries, may have a bright silvery streak running longitudinally down the centre, due to reflection of light from the convex cylindrical surface.

The mode of branching of the vessels is subject to great variation, though it is derived from the fundamental type described. The variations are generally of no practical importance. The primary division of the superior and inferior trunks usually takes place on or very near the disc. The nasal branches run much more radially than the temporal, which make a very decided sweep to avoid the macula.

The Macula lutea is situated about 3 mm. or 2 disc-diameters (2 p.d.) to the temporal side of the edge of the disc, and is a little below the level of the horizontal diameter. It is very difficult to see without a mydriatic, for the bright light on this most sensitive spot causes maximal constriction of the pupil: the corneal reflex then usually obliterates all view. It may generally be seen by using very dim illumination.

The macula varies in appearance according to illumination, refraction, complexion, &c. In general, it is a small circular area of a deeper red than the surrounding fundus, sometimes looking almost black. There is nearly always a *foveal reflex*, due to reflection of light from the walls of the foveal depression. This is most frequently seen as a silvery ring of light, hiding everything behind it: it may be circular or oval, according to the incidence of the light and the refraction of the eye. Often there is an intensely bright spot at or close to the fovea, also due to reflection. The deeper red of the macula is due to the thinness of the retina, so that the specially vascular choriocapillaris of this region is seen more clearly: shadows thrown by the edges of the foveal depression may contribute a share to the deepening of the colour.

The macular region is supplied by twigs from the superior and inferior temporal arteries, and by small branches coming straight from the disc. There are no retinal blood vessels actually at the fovea (Fig. 5), and none can be seen ophthalmoscopically for a little distance around. Occasionally there are small arteries (cilio-retinal) derived from the ciliary system. They start near the edge of the disc, run inwards, and then bend sharply outwards towards the macula (Fig. 85).

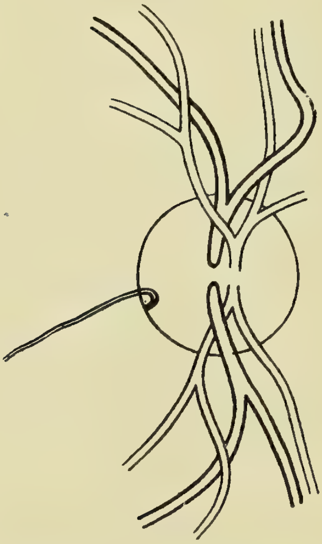


FIG. 85.—A cilio-retinal artery.

The General Fundus.—The appearance of the general fundus varies enormously within healthy limits. It is especially determined by the complexion of the patient, which may be taken as an index of pigmentation in different parts of the body. In people who are neither very dark nor very light the spaces between the retinal vessels show a uniform redness, occasionally with a very delicate punctate stippling, especially towards the periphery. In albinos the choroidal vessels are seen clearly, the spaces between them being white, due to the sclerotic shining through. In very dark people the fundus is a

darker red, and indications of the choroidal vessels are often seen as indefinite brighter red streaks. Sometimes the pigment between the choroidal vessels is particularly dense, or the pigment is deficient in the retinal pigment epithelium, whilst the choroid is deeply pigmented: the choroidal vessels are then seen separated by deeply pigmented polygonal areas (*tigroid* or *tesselated fundus*) (Plate III., Fig. 2).

There is no difficulty in distinguishing the choroidal from the retinal vessels when both are visible (Cf. Plate X., Fig. 2). The former are broader and ribbon-like, without any central reflex streak : they anastomose freely, unlike the retinal vessels, which do not anastomose at all. Moreover in certain parts, their anatomical distribution is very characteristic (*vide* p. 14).

All the details of the fundus will be seen much better by the direct method, unless the eye is very myopic, when the magnification is so great and the area seen is so small that it is difficult to find any given spot.

Under normal conditions no pulsation can be seen in the retinal arteries. The retinal veins may, however, often be seen to pulsate at or near the edge of the disc, or indeed wherever they take a very sharp bend. This is usually due to transmitted pressure. The blood pressure is lowest in the veins near the disc, and there is a certain amount of obstruction to the flow of blood as the vessels pass through the narrow neck at the lamina cribrosa. With each arterial pulsation the intraocular pressure is suddenly raised slightly, so that the pressure on the outside of the walls of the veins is increased. This causes a sudden increased obstruction to the outflow of blood from the eye ; the wall of the vein becomes slightly compressed, recovering itself during the arterial diastole. Hence pulsation is observed, and it will be seen best where the intravenous pressure is least, viz., nearest the heart, *i.e.*, at the disc, and where there is any additional obstruction, viz., near the lamina cribrosa and at any sharp bend. The venous pulsation can be increased or made manifest if absent by slight pressure on the globe, which has the effect of increasing the intraocular pressure. This normal venous pulse is seen without artificial aid ~~from~~ pressure on the globe in 70 to 80 per cent. of people. It will be noticed that it is diastolic; it has therefore been called the *negative venous pulse.*

Two other forms of venous pulse occur in pathological conditions.

The *positive venous pulse* is presystolic, continuing into the systolic phase: it is due to tricuspid regurgitation, and is permitted by the normal insufficiency or absence of valves in the jugular veins. The *transmitted centripetal venous pulse* is an accentuation of the normal tendency of the pulse wave to progress through the capillaries into the veins, owing to the intraocular tension. It is due to venous congestion, with or without increased vis a tergo.

Arterial pulsation is always pathological. The blood pressure in the ophthalmic artery is only a few mm. Hg. below that of the carotid in animals. Considering the differences of blood supply it would be unwise to apply the result directly to man, but there is no doubt that the pressure in the central artery is far above the intraocular pressure. It would not be surprising, therefore, if the pulse wave were transmitted and could be seen. There are two reasons which militate against this: (1) the intraocular pressure damps the pulsation, and the increase in pressure which accompanies each pulsation is spread over the whole volume of the contents of the globe, and is transmitted to the plastic sclerotic; (2) such pulsations as survive this damping effect are too slight to be observed in such small vessels by ordinary ophthalmoscopic examination.

Two types of arterial pulsation occur pathologically: (1) a true pulse wave, accompanied by locomotion of the vessels; (2) an intermittent flow of blood, or pressure pulse. In the latter the arteries fill only with the heart beats, being empty between them; it is only visible on the disc, and may be produced in a normal eye by external pressure upon the globe by a finger applied to the lid. This type of pulsation is a pure pressure phenomenon, and is caused by any considerable increase of intraocular tension with normal or lowered blood pressure, *e.g.*, in glaucoma, or by any considerable diminution of blood pressure with normal intraocular pressure, *e.g.*, in syncope, orbital tumours, &c. The true arterial pulse occurs in cases of aortic regurgitation or aneurysm, in exophthalmic goître, &c.; it is not confined to the disc. It is equally a pressure phenomenon, but the differences of pressure are smaller.

Capillary pulsation is seen only in aortic regurgitation as a systolic reddening and diastolic paling of the disc.

The order of examination of the details of the fundus should be systematic. Applying the indirect method we obtain a general view. The patient is instructed to fix the gaze in such a direction that the disc is brought into view. It will occupy about the centre of the field, and a considerable area around will be visible. Any gross abnormality is detected at once. The shape and colour of the disc, the arrangement of the vessels, the colour of the choroidal reflex (its uniformity or tesselation), gross abnormalities (white or pigmented spots, &c.), are readily noted. The patient is then directed to look up to the ceiling, to the right, to the left, and down to the ground; in the latter position the lid is gently raised by a finger of the hand which is holding the large lens, as otherwise it will cover the pupillary area. In this manner the periphery of the fundus is brought into view. Even when the central parts of the fundus are uniformly tinted the periphery often displays traces of the choroidal vessels, associated with greater pigmentary stippling or a diminution of pigment. Only minute investigation with the direct method can show whether this is normal or pathological. The characteristic type and distribution of the pigmentation of retinitis pigmentosa is best demonstrated in this manner.

Having thus obtained a good general idea the systematic examination is repeated by the direct method, paying special attention to points which the indirect method has left uncertain. The details of the disc—physiological or pathological cupping, blurring of the edges or swelling, abnormalities of the edges in the form of crescents and so on—are inspected. Attention is then turned to the vessels. Abnormalities in arrangement or distribution, the presence of cilio-retinal vessels, &c., are noted. The details of the individual vessels—their relative size, irregularity of contour or varicosity, visibility of the walls as shown by the presence of white lines along the edges, abnormalities of the reflex streak, &c.—are investigated. The vessels are traced towards the periphery and the smaller vessels inspected. Changes often occur near the vessels, such as small hæmorrhages, white spots of exudate, &c.; these are carefully looked for.

Next, the macula is examined: this should never be omitted. It may be brought into view by telling the patient to look into the light: with unintelligent patients it is best to say nothing, but fix the temporal edge of the disc and pass horizontally outwards for a distance of about two papilla diameters (a convenient unit in ophthalmoscopic topography), when the macula will be found. If the patient is not under a mydriatic or the pupil movements are not abolished by disease (optic atrophy, &c.) the light should be lowered so that the constriction of the pupil may be reduced to a minimum. The corneal reflex is always troublesome, but has to be dodged. Any abnormality at or near the macula is of the utmost importance. Black or white spots are often very difficult to distinguish from shadows or reflexes: if

either can be made out by any means (*e.g.*, the use of a concave lens) to have a definite sharp contour, and if they do not seem to shift in the slightest degree when a minute movement is made with the mirror, it may be concluded that they are pathological entities.

Finally, the periphery of the fundus is investigated. It is important to know how far out we can see by the direct method. It can be shown theoretically and proved practically that the fundus can usually be seen only a short distance beyond the equator of the eye. There is therefore a zone behind the ora serrata which is invisible. The periphery, even in an emmetropic eye, is usually best seen with a low convex lens, owing to the obliquity of the axis of the rays as they pass through the crystalline lens.

CHAPTER IX.

FUNCTIONAL EXAMINATION.

In the second great group (*vide* p. 91) of ophthalmic patients there are no manifest objective signs of disease and we are dependent at the outset upon the subjective symptoms of which the patient complains. In these cases, after a rapid, but careful, external examination to eliminate any objective sign which may have escaped observation it is usually most convenient to proceed at once to the functional or subjective examination. Whether this produces evidence of abnormality or not, it is imperative to proceed then to the systematic internal examination with the ophthalmoscope.

On the other hand, in the first group of ophthalmic patients, in spite of external signs of disease which may suffice to account for the symptoms, it is the surgeon's duty to eliminate as far as possible all other evidence of abnormality. Ophthalmoscopic examination may be impossible at the first visit, and subjective functional testing may be so vitiated by the obvious disease as to afford no useful information. In such cases functional and internal examination should be postponed until a future visit, but in no case should it be entirely omitted. It should be borne in mind that, rightly or wrongly, the surgeon is liable to be held responsible for the discovery of any disorder of the eye which manifests itself at or about the time of his examination.

The functional examination of the eye proper consists in testing the acuity of the forms of visual perception

which have been already mentioned: viz., the light sense, the colour sense, and the sense of form. They are usually tested in the reverse order. Each eye must be tested separately throughout. In the preliminary examination it is sufficient to test first the acuity of central vision for distant and for near points, then roughly the field of vision, and finally the reactions of the pupils, afterwards proceeding forthwith to the ophthalmoscopic examination. It may then be necessary to revise the rough test of the field of vision by taking it with greater precision, to supplement the tests with white light by those with coloured objects, both in the central and peripheral parts of the field, and to estimate, more or less accurately, the light minimum and the light difference. In the routine examination it is well to test roughly the condition of the extrinsic muscles

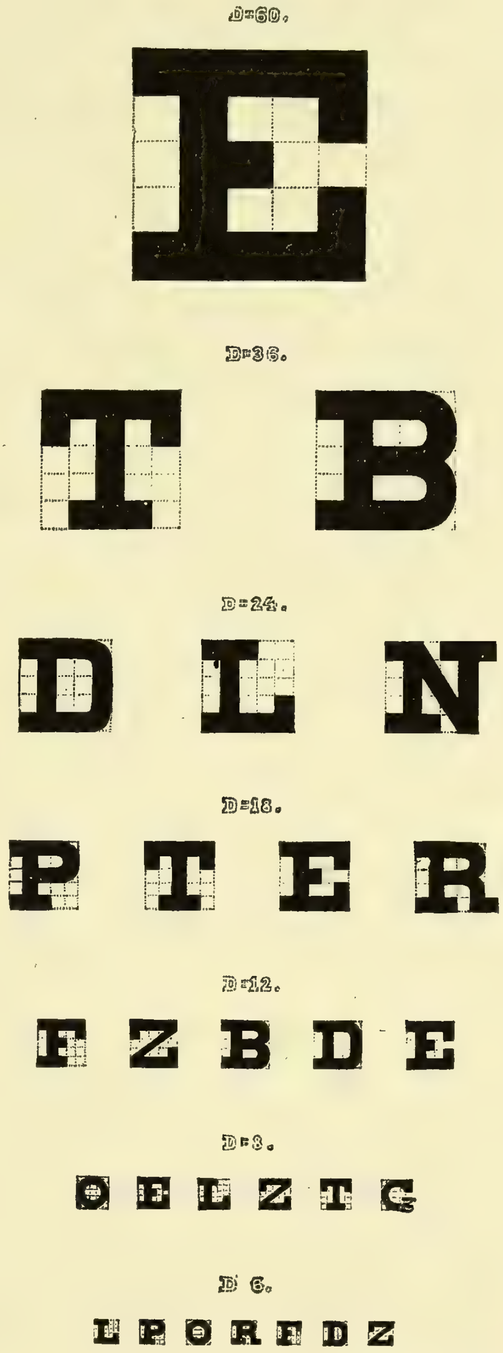


FIG. 86. — Snellen's Distant Test Types (reduced). The lines, from above downwards, should be read at 60 metres, 36 metres, 24 metres, 18 metres, 12 metres, 9 metres, and 6 metres respectively, *i.e.*, at these distances the letters subtend a visual angle of 5′.

before proceeding to the ophthalmoscopic examination (Section V.).

The Acuity of Vision.—The acuity of distant central vision is now almost invariably tested by means of Snellen's Test Types (Fig. 86). These are constructed upon the fundamental principle that the average minimum visual angle is 1 minute.

The types consist of a series of letters diminishing in size. The breadth of the lines of which the letters are composed is such that the edges subtend an angle of 1 minute at the nodal point of the eye. Each letter is of such a shape that it can be placed in a square, the sides of which are five times the breadth of the constituent lines (Fig. 86). Hence the whole letter will subtend an angle of 5 minutes at the nodal point of the eye (Fig. 87).

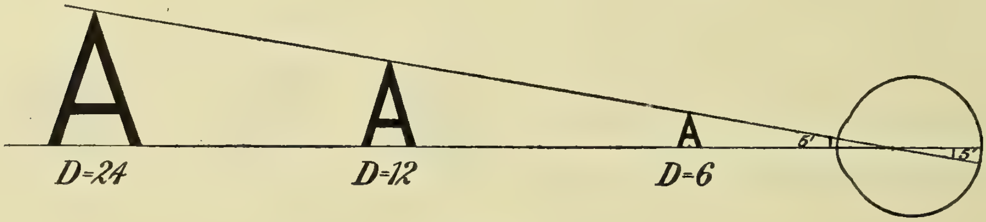


FIG. 87.

In order that these conditions may be fulfilled it is obvious that such a letter to be used as a test a long distance from the eye must be larger, and the constituent lines must be broader than in the case of a letter to be used nearer the eye. In Snellen's types the largest letter will subtend 5 minutes at the nodal point if it is 60 metres from the eye. Those in the second line will subtend 5 minutes if they are 36 metres from the eye; those of the consecutive lines 24 metres, 18 metres, 12 metres, 9 metres, and 6 metres. Sometimes smaller letters corresponding to 5 metres, 4 metres, 3·5 metres are used.

A person with average acuity of vision ought therefore to be able to read the top letter at 60 metres, the second line at 36 metres, the third at 24 metres, and so on. Now, it would be very inconvenient to have to alter the distance between the patient and the letters to this large extent. A numerical convention which gives a fair comparative estimate of the value of different acuities of vision has therefore been adopted.

The patient is kept at a fixed distance from the types. This distance should never be less than 5 metres, or preferably 6 metres. At such a distance the divergence of the rays in the small bundle which enters the pupil is so slight that it can be neglected, the rays being considered parallel. If the distance were 3 metres, for example, an appreciable amount of accommodation would have to be exerted by an emmetropic eye in order to bring the rays to a focus upon the retina: hence the estimate of distant vision would be fallacious.

A normal patient 6 metres from the types ought to be able to read every letter from the top to the end of the 6 metre line; many people can read more in a good light. Suppose the patient can only read the 18 metre line. His distant vision is obviously defective. The numerical convention which is used to record this is a fraction in which the numerator is the distance at which he is from the types, and the denominator is the distance at which a person with normal vision ought to be able to read the last line which he succeeds in reading. The patient under consideration will therefore have his distant vision recorded thus: $V = \frac{6}{18}$. The normal patient's vision will be $V = \frac{6}{6}$.

These fractions give an indication that the normal patient's vision is unity, whilst the other patient's is one-third as good. The fraction should not be reduced in this manner, because it is only an accurate numerical estimate under special conditions. It should be used merely as a convention, just as numbers are used to indicate variations in tension, though this is far less defensible. If the fraction is reduced much valuable information is lost. In its original form it indicates the actual types used and the actual distance away from the types; it therefore eliminates doubt as to the accuracy of the application of the test.

If the patient cannot read the largest letter he is told to walk slowly towards the types. At a certain distance he may be able to see the top letter. He should then be moved back a little, since he may not have understood exactly where to look. In this manner the farthest point at which he can distinguish the top letter is determined. If this is 3 metres, the vision is recorded thus—V = 3/60. Perhaps he is unable to see the top letter even close to it. In that case he is asked to count the extended fingers of the surgeon's hand, held up at about 1 metre against a dark background: the distance is varied to obtain about the maximum. This is recorded thus—V = fingers at 1 metre. If he cannot count fingers he is told to look at the light, either artificial or the window; the surgeon's hand is then moved between the eye and the light. If he can distinguish the movements of the hand it is recorded as V = hand movements. If he is unable to distinguish hand movements he is taken into the dark room and the light is alternately switched on and off, or light is concentrated on his eye with a convex lens or with the ophthalmoscope mirror, and he is asked to say when the light is on the eye and when it is off. If he succeeds in doing this, V = p. l. (perception of light). If he fails to see the light at all the vision is recorded a V = no p. l.

It does not follow that a patient who reads 6/6 is emmetropic: he cannot be myopic unless he is screwing up his eyes, and in any case he cannot be very myopic. He may, however, be hypermetropic, for by an effort of accommodation he can bring the practically parallel rays emitted by the letters to a focus on his retina. We wish, then, to find out if he is accommodating. It is done by finding out the highest convex lens, placed before his eye in a testing spectacle frame, with which he can still read 6/6.

Directly a convex lens is placed before the eye in a patient who has good accommodative power it tends to make objects look blurred. Hence it is best to start with a convex lens which will quite definitely blur the types, and then gradually counteract it by placing concave lenses of increasing strength in contact with it. A + 4 D lens is put in front of the eye. Probably the patient now reads only a few lines. With the + 4 D still in position a — 0·5 D is put in front of it; the patient perhaps reads another line. The — 0·5 D is replaced by a — 1 D; he still fails to read 6/6. The — 1 D is replaced by — 1·5 D; we will suppose that he now reads 6/6. This proves that he has average normal vision with a + 2·5 D lens. With the assistance, therefore, of a 2·5 D convex lens he can relax his accommodation the corresponding amount. It by no means follows that this represents the total amount of his hypermetropia. As has already been pointed out (*vide* p. 62), the younger the person the greater the capacity to accommodate. Young people, therefore, have great facility in accommodating. If they are hypermetropic this fund has been drawn upon for a long period, so that a condition of partial contraction of the ciliary muscle becomes normal to them. Sometimes even there is excessive contraction of the muscle, so that they become artificially myopic, a condition which is called "spasm of accommodation"; it is probably diagnosed more often than it occurs.

The younger the patient, therefore, the easier it will be for him to accommodate, and the more difficult to relax his accommodation completely. That part which he can relax when convex lenses are used as described above is called his *manifest hypermetropia* (Hm.). The part which he is unable to relax, which can only be determined by paralysing the ciliary muscle, is called his *latent hypermetropia* (Hl.). The sum of the manifest and latent hypermetropia is called the *total hypermetropia*. In extreme youth nearly all the hypermetropia is latent: the lens is so resilient that it is impossible to prevent it responding to the slightest stimulus. As the lens becomes less plastic more and more of the hypermetropia becomes manifest, until, finally, when accommodation disappears entirely, all the hypermetropia is manifest. The older the patient, therefore, the nearer the manifest hypermetropia represents the total amount.

The vision of the patient in the above example is usually recorded thus: $V = \frac{6}{6}$, Hm. + 2·5.

With intelligent patients who do their best to read as many letters as possible without continual encouragement from the surgeon, the manifest hypermetropia is obtained with less trouble by simply putting up convex lenses of gradually increasing strength until the last line which was read with the unaided eye becomes blurred.

An older patient than the one considered in the previous example will very likely read more with a convex glass than without it. Thus a patient of fifty-five may perhaps read only 6/12, whilst with a + 2 D he reads 6/6. This man has a manifest hypermetropia of 2 D. Since he is fifty-five years of age he has only 1 D of accommodation left (*vide* p. 63). When he reads with the unaided eye

he uses up this 1 D in getting as far as 6/12; he is unable to accommodate any more, so the lower letters are too blurred to read. He may manage to read 6/6 with the assistance of a + 1 D, since this, with the remnant of his accommodation, will fully correct his hypermetropia. On seeking the highest convex glass we find he can read 6/6 as well or better with + 2 D. This, therefore, represents his manifest hypermetropia. Such a case is recorded—$V = \frac{6}{12}$, Hm. $+ 2 = \frac{6}{6}$.

Apart from counteracting a convex lens as described above the student should never use concave lenses in testing the distant vision, unless the patient is under a mydriatic. An emmetrope or even a hypermetrope, if neither is presbyopic, will read 6/6 quite well with weak concave lenses in front of the eye; he simply accommodates the amount which is requisite to counteract the lens. Hence, unless the patient is under the influence of a mydriatic, we learn nothing from the procedure; it is therefore redundant.

Having tested the distant vision and determined the amount, if any, of the manifest hypermetropia, the near vision should next be tested. For this purpose test types for near vision are used (Fig. 88). Snellen's are constructed on exactly the same principle as the distant ones, and are therefore most scientifically accurate. For actual reading, however, people can often read types which are smaller than Snellen's smallest if the lines forming the letters are a little broader. This is chiefly due to the fact that an idea of the shape of letters will often permit them to be accurately guessed when they are not clearly visible. This is, indeed, an objection to the use of letters as test objects at all. Jaeger's near test types, which are very frequently used, are simply the ordinary printers' founts of type, from the smallest

J. 1 (Sn. 0.5). 50 cm.

As she spoke, Moses came slowly on foot, and sweating under the deal box, which he had strapt round his shoulders like a pedlar. "Welcome, welcome, Moses! well, my boy, what have you brought us from the fair?"—"I have brought you myself" cried Moses, with a sly look, and resting the box on the dresser. "Ay, Moses," cried my wife, "that we

J. 2 (Sn. 0.6). 60 cm.

five shillings and twopence is no bad day's work. Come, let us have it then."—"I have brought back no money," cried Moses again. "I have laid it all out in a bargain, and here it is," pulling out a bundle from his breast: "here they are; a gross of green spectacles, with silver rims and

J. 4 (Sn. 0.8). 80 cm.

mother," cried the boy, "why won't you listen to reason? I had them a dead bargain, or I should not have brought them. The silver rims alone will sell for double the money."—"A fig for the silver rims," cried my wife, in a passion: "I dare

J. 6 (Sn. 1). 1 m.

the rims, for they are not worth sixpence; for I perceive they are only copper varnished over."—"What!" cried my wife, "not silver! the rims not silver?"—"No," cried I, "no more silver

J. 8 (Sn. 1.25). 1.25 m.

with copper rims and shagreen cases? A murrain take such trumpery! The blockhead has been imposed upon, and should have known his company better."—"There,

J. 10 (Sn. 1.5). 1.5 m.

the idiot!" returned she, "to bring me such stuff: if I had them I would throw them in the fire."—"There again you are wrong, my dear," cried I;

J. 12 (Sn. 1.75). 1.75 m.

By this time the unfortunate Moses was undeceived. He now saw that he had

J. 14 (Sn. 2.25). 2.25 m.

asked the circumstances of his deception. He sold the horse, it

FIG. 88.—TEST-TYPES FOR NEAR VISION.

Jaeger Test-Types, with approximate Snellen equivalents, and the most remote distances at which each should be read with average normal vision.

Although children often get into the habit of holding books
unnecessarily close.

upwards (nonpareil, minion, &c.). They are sufficiently accurate for practical purposes.

The patient is told to hold the test card. The position where he holds it of his own accord will often impart useful information. If he is old and holds it a long distance away, he is most likely to be an emmetropic or hypermetropic presbyope. If he holds it closer than the ordinary reading distance and reads the smallest type fluently, he is probably myopic, whatever his age may be.

Take first the example of an emmetrope. We find that he reads 6/6, that he has no manifest hypermetropia, and that he reads Jaeger 1, holding it of his own accord at ordinary reading distance (22 cm. or 9″). This is recorded—V = 6/6, no Hm., J. 1. If no distance is stated in recording the near vision it is understood to be the normal distance.

Take now a patient who reads only 6/60, has no manifest hypermetropia, but reads Jaeger 1 fluently, only, however, when the card is held much closer than normal to the eye. In this case the distance at which the card is held should be guessed or measured. Let us suppose that it is about 5 inches. This is recorded—V = 6/60, no Hm., J. 1 at 5″.

Take now a patient of fifty-five who reads 6/6, and has no manifest hypermetropia. We give him the near types, and he holds the card a long distance off, but even so cannot read Jaeger 1. In this case it is waste of time to discover exactly which type he can read, and to measure the distance at which he can read it. We know that as he is fifty-five he has only 1 D of accommodation remaining (*vide* p. 63). What we wish to know is whether he can read Jaeger 1 at ordinary reading distance if we correct his presbyopic defect. We therefore at once put up a + 3 D lens before the eye, tell him to hold the types closer, and ask him if he can read the smallest. He will probably do so easily. This is recorded thus—V = 6/6, no Hm., c̄. + 3 = J. 1.

Finally, take a patient of fifty who reads 6/12, but with + 2 D 6/6. He will hold the near types a long distance away as in the last example; if we investigate the question he will not be able to read nearly as well even a long distance away as the last patient. He has only 2 D of his accommodation remaining, but he also has 2 D of hypermetropia. We cannot therefore expect him to read Jaeger 1 at ordinary reading distance unless we not only correct his presbyopia but also his hypermetropia. We therefore at once put up a + 4 D, and find that he reads Jaeger 1 at ordinary distance quite well. This is recorded thus—V = 6/12, Hm. + 2 = 6/6, c̄. + 4 = J. 1.

The ordinary rule of presbyopic loss of accommodation, viz., 1 D for each five years after forty, is rather a liberal allowance, and we often find that patients are more comfortable with slightly less (*vide* p. 64). In no case should more be ordered.

An indication of the *range of accommodation* is given by the knowledge of the manifest hypermetropia, combined with the ability to read the small types at ordinary reading distance. Strictly, the accommodation should be more carefully tested in each case, but it is often neglected.

The method adopted to find the near point of the eye has already been mentioned (*vide* p. 59). For practical purposes it is sufficient to use the smallest Jaeger or Snellen near type and approach it nearer and nearer to the eye until it can no longer be read. The last point at which it can be read gives the near point. The distance of the near point from the eye is then measured with a tape. This distance is transformed, if necessary, into millimetres (25 mm. = 1 inch), and the range of accommodation is deduced from the formula A = P − R (*vide*

Only in very exceptional cases.

p. 61). Of course, the full range of accommodation in a hypermetrope cannot be accurately arrived at unless the total hypermetropia is known; this may require the use of a mydriatic. Practically, however, we are chiefly concerned in discovering paralysis or paresis of accommodation, such as may occur after diphtheria or previous use of a mydriatic. In these cases the knowledge of the distance of the near point is sufficient.

The next step—one which is far too often neglected—is in every case to test the *pupil reactions* and record them. If the visual tests have shown deficiency it may be necessary to use a mydriatic, in which case it will be impossible to test the pupil reactions at a later stage of the same visit; hence the importance of recording them at once.

We should also test the field of vision roughly.

The Field of Vision.—There are several methods of testing the field of vision.

(1) A rough, but very useful, method which should be applied in every case, at any rate if there is the slightest suspicion of defect, is as follows:—

The surgeon stands facing the patient at a distance of 18 inches to 2 feet. The patient covers his left eye with the palm of his hand. He is told to look straight into the surgeon's left eye. The surgeon closes his right eye. He then moves his hand in from the periphery towards the common line of vision of the patient's right and his own left eye, keeping his hand in the plane half-way between the patient and himself. Directly he sees it himself the patient ought to say that he also sees it. The movements of the hand are repeated in various parts of the field—above, below, to the right, to the left, and so on.

This method is extremely simple, rapidly applied, and an excellent test. It will be seen that the surgeon tests the range of the patient's field by that of his own, which may be considered normal; moreover, he is continually watching the patient's eye, so that he can at once observe any deflection from the point of fixation.

The gross defects in the field which are most likely to escape recognition are homonymous and bitemporal hemianopia, the latter usually due to acromegaly or tumour of the pituitary body (Chap. XX.). They may be roughly tested for by telling the patient to look straight at the surgeon, situated as before, both eyes being open. The surgeon holds up both hands, one in each temporal field, and the patient is told to touch the surgeon's hand. If he asks "Which one?" he has not bitemporal hemianopia, since he sees both hands. If he promptly points to one hand he should be asked if he sees the other; if he does not, he probably has homonymous hemianopia.

If any defect is indicated by these methods or is suspected from other features of the case it must be accurately mapped out and recorded with the perimeter.

(2) *The Perimeter.*—The perimeter consists essentially of an arc, marked on the back in degrees of a circle, capable of being revolved round a pivot which the patient fixes with the eye under examination (Fig. 89). The chart, which has concentric circles marked upon it, corresponding with the degrees on the arc, is under the surgeon's control at the back of the perimeter. In self-registering perimeters, which are almost invariably used, the readings are recorded by perforations with a sharp point.

The details of taking a perimetric chart can only be taught by actual demonstration. It will suffice to emphasise here the chief procedures to be followed in order that accuracy may be attained.

The patient is seated with his back to the light. His chin rests upon the chin-rest; the face is vertical and not

These should be mapped out with the same accuracy as the extreme limits of the field. If the scotomata are small the limits may be determined with an intelligent patient best with a very small object, *e.g.*, 2 mm. square.

Having mapped out the field for white the process should be repeated with similar, but coloured, objects. Red or green should be used first, then blue or yellow ; ~~if~~ the red and green are complementary, *i.e.*, if the tints ~~when~~ combined would produce white, their fields will be ~~found~~ ~~to be identical ; the same applies to the blue and yellow.~~ Special care must be taken to investigate the central part of the field for red and green, since conditions are not uncommon, *e.g.*, tobacco amblyopia, in which these

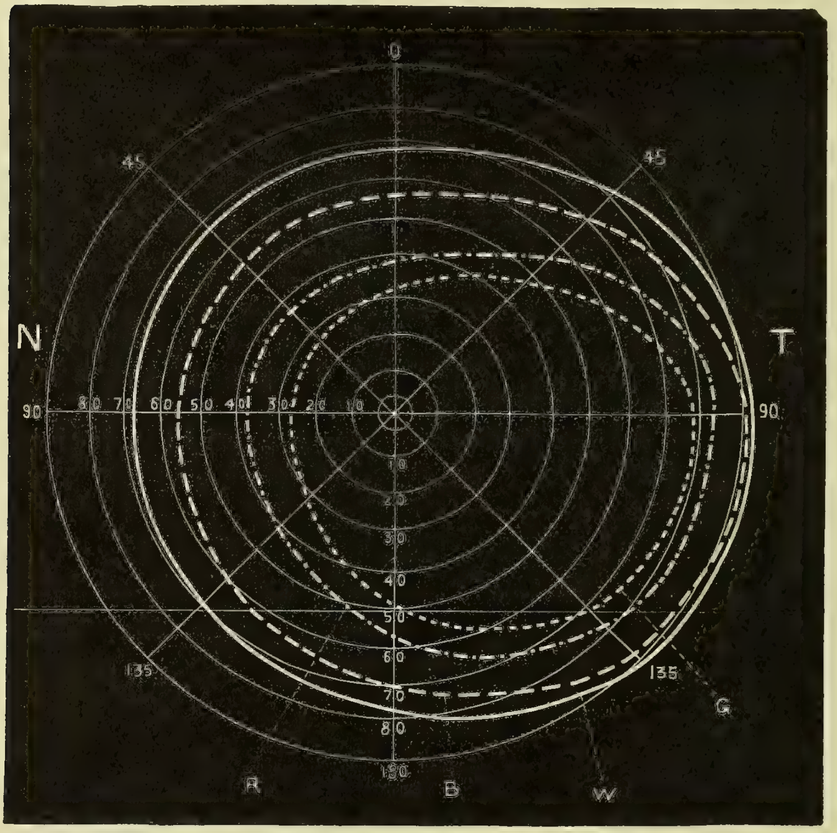


FIG. 90.—Perimeter chart of right eye (Landolt). T, temporal side ; N, nasal side ; W, for white object ; B, for blue ; R, for red ; G, for green.

(7)

① Under ordinary circumstances, the blue field is largest, slightly smaller than the white: then follow the yellow, ~~green, red,~~ red & green in the order named (Fig. 90). There is a particular purplish red & a particular green which have ~~coincident~~ the same fields; & similarly a particular blue & a particular yellow — These pairs of colours are complementary, i.e. a mixture of the red & the green, or of the blue & the yellow produces white.

Gradually /
shape of the remaining area like that of a projection forwards, being often modified [illegible] when the field is taken in the ordinary manner by

(8) The size varies with the illumination, the size of the test object, the contrast of the test object with the background, & the state of adaptation of the eye.

(9) The limits of the colour fields vary not only with the intensity of the light, but also with the saturation of the colours, & also with the size of the object. If these are sufficiently great colours may be recognised almost, if not quite, at the periphery.

¶ Special care must be taken to investigate the central part of the field for red & green, since conditions are not uncommon, e.g., tobacco amblyopia & retrobulbar neuritis, in which these colours are not recognised by central vision (central relative scotomata). The 5 mm square should be placed over the point of fixation & the colour changed: blue & yellow will be recognised at once, but not red & green.

colours are not recognised by central vision (*relative scotomata*).

The extent of the normal field, with a 10 mm. square, under good illumination, is shown in the accompanying chart (Fig. 90). The peculiar shape is ~~largely~~ due to the interference caused by the nose and the brows. It is seen that the field for white extends upwards 45°, outwards rather more than 90°, downwards 70°, and inwards 60°.

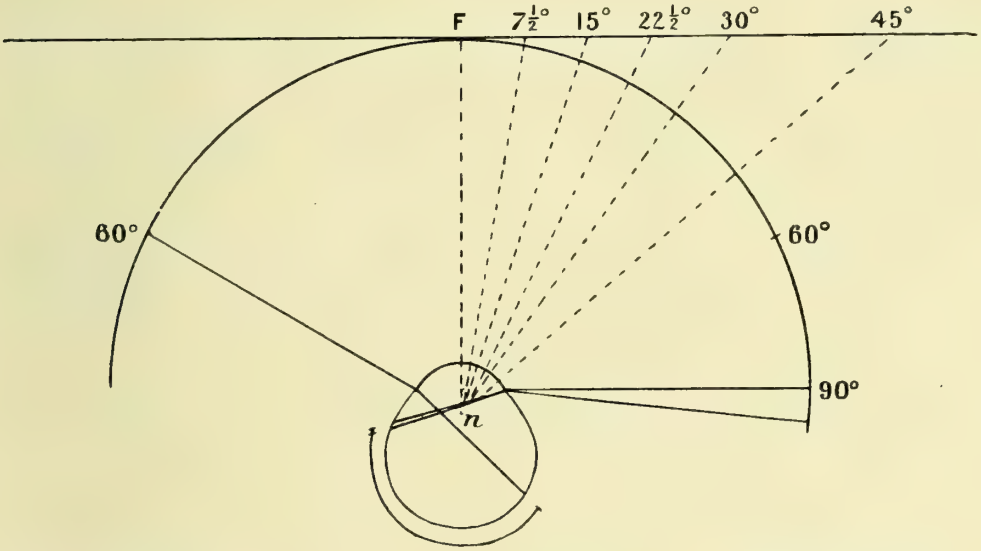


FIG. 91.—Diagram of the right eye, showing the relationship of the retina to the degrees of the perimetric arc, and the relative value of the latter when projected on a tangent scale. *n*, nodal point. F, point of fixation.

The field for blue and yellow is roughly 10° less in each direction, that for red and green another 10° less.

Even the ordinary perimetric observation is a relatively rough test and purely subjective. It must always be regarded with suspicion in dull or neurotic patients. The maximum field is obtained from objects which subtend a visual angle of ½° : the ordinary 10 mm. object at the distance used—30 cm.—corresponds with a visual angle of 2°.

(3) For more accurate investigation of details another method must be employed, but it is applicable only to

the central area. It consists in placing the patient 2 metres from the centre of a large black screen (2 metres or more broad). The patient fixes a spot in the centre of the screen and smaller circular discs of ivory, 1 mm. to 10 mm. in diameter, attached to a long black rod are brought in from the periphery on a level with the screen. At this distance a 3 mm. object subtends a visual angle of about 5 minutes. It will be noticed that, the angles being projected on to a flat surface, tangents are recorded, not angles themselves as with the arc. Hence only a small area can be investigated, and the distortion must be taken into account. Some points of diagnostic importance which cannot be elicited by the perimeter can be brought out by this method.

If the charts of the two eyes are superposed there will be a large central area which is common to both eyes: this is the *field of binocular vision.*

The Light Sense may be roughly tested by means of Bjerrum's test types, which consist of Snellen's test types printed grey on a grey background of different intensity; [illegible] more exactly by [illegible] [illegible] — No simple means of accurately testing the light sense has yet been devised, nor [illegible] the clinical [illegible], such as Förster's, [illegible]

The Colour Sense requires elaborate apparatus for its scientific investigation. [illegible] will be discussed later (p. 422).

Diseases [illegible] in children [illegible] about 30 percent of all
[illegible] disease [illegible]

SECTION III.

DISEASES OF THE EYE.

CHAPTER X.

DISEASES OF THE CONJUNCTIVA.

THE conjunctiva shows very considerable variations in appearance at different ages and in people who follow various employments. The peculiarities of colour, vascularity, laxity, &c., which are consistent with health can be learnt only by repeated observation.

It is necessary for a scientific appreciation of pathological conditions to be cognisant of the normal structure of a part. The conjunctiva is divided into two portions, palpebral and bulbar; the folds uniting these parts are the fornices. The palpebral conjunctiva is said to commence at the anterior margin of the edge of the lid, but from this point to the posterior margin of the edge (the intermarginal strip) and for about 2 mm. beyond (to the sulcus subtarsalis) there is a transitional zone covered with stratified epithelium and partaking of the characters of both skin and conjunctiva (Chap. XXIX.). There are two layers of epithelium over the palpebral conjunctiva: from the fornices to the limbus the epithelium becomes gradually thicker, forming eventually again a stratified epithelium. Below the epithelium is an adenoid layer, consisting of loose connective tissue containing mononuclear lymphocytes: below this a fibrous layer, much denser and passing insensibly into the underlying tissues—lid or sclerotic. The palpebral conjunctiva is firmly adherent to the tarsus, whilst the bulbar portion is freely movable over the sclerotic except close to the cornea.

Bacteriology. — The conjunctival sac is practically never free from organisms. Most are non-pathogenic, but some of these are morphologically identical with pathogenic organisms. Diplococci indistinguishable from pneumococci are found; they may be innocuous to animals or prove themselves true pneumococci. It may be stated at once that the pneumococcus is one of the most dangerous organisms in the pathology of the eye. Another bacterium, the so-called xerosis bacillus, is morphologically identical with the diphtheria bacillus; it can only be distinguished by skilled examination of cultures. Staphylococci are found; they are relatively innocuous in the absence of other organisms, but play an important part in mixed infections. Streptococci, Bac. coli, &c., are pathogenic, but rare. Other pathogenic organisms — gonococci, Koch - Weeks' bacilli, diplobacilli—will be discussed later.

INFLAMMATION OF THE CONJUNCTIVA.

Conjunctivitis. — Inflammation of the conjunctiva manifests itself in many grades and many types. It is always accompanied by hyperæmia and by increased secretion. The hyperæmia varies in degree and in distribution: the secretion varies in nature and amount.

Hyperæmia may be transitory, or recurrent and chronic. The former is caused by temporary irritation, as by a foreign body in the conjunctival sac (which includes the surface of the cornea): in such a case the increased secretion is almost wholly a reflex secretion of tears.

(12) l. Owing to the relatively low temperature of the conjunctival sac, due to exposure, evaporation of lacrymal fluid + moderate blood supply, ~~organisms do~~ bacteria do not propagate themselves readily. The tears are not a good culture medium, though since they contain no hæmolysins or bacteriolysins, they cannot be regarded as actively bactericidal. They contain no agglutinins, & diphtheria antitoxin does not pass into them when present in the blood. Hence they act principally in a mechanical manner, washing away deleterious agents & their products.

The presence of dust, even if it be sterilized, augments the bacterial contents of the conjunctival sac (Römer). It is also increased by bandaging owing to the arrest of movement of the lids & the raised temperature of the sac.

(13) l. The conjunctiva of many people is immune to pneumococcus infection, though the same germs transferred to other persons will excite a violent inflammation.

(14) l. Staphylococcus albus & xerosis bacilli are practically always present in the normal conjunctival sac. There are reasons for thinking that their presence favours the growth of pathogenic bacteria: thus xerosis bacilli promote the multiplication of influenza bacilli both in cultures & on the conjunctiva.

→, concretions in the palpebral conjunctiva (p. 211), ingrowing lashes (v. p.), etc.

(15) l. A foreign body, especially a grain of corn or the winged seeds of an insect, may be retained in the fornix & set up a violent irritation of conjunctivitis. If it be limited to the lower fornix it may be artificial in malingerers & hysterical patients.

(16) b Strong bright light and especially exposure to tropical sunlight, acts partly by the glare due to the luminous rays, partly by the chemical action of the actinic & especially the ultra violet rays, & partly by the heat, which is chiefly due to the infra-red rays.

(17) b Points characterizing the symptom of hay fever, in this case there is an excess of eosinophile leucocytes in the conjunctival secretion.

Recurrent or chronic congestion may be caused by the conditions of life—dusty, ill-ventilated rooms, exposure to strong light, &c. It is often due to conditions remote from the conjunctiva itself. Very frequently it is a reflex irritation due to errors of refraction ; in such cases the edges of the lids may participate. Other causes are found in errors of metabolism—gout, over-eating and drinking, and so on.

Simple hyperæmia of the type described causes a sense of discomfort, often described as tightness, grittiness, inability to keep the eyes open, tiredness, &c. Bright light is resented, but there is seldom true photophobia. The conjunctiva often looks quite normal until the lower fornix is exposed, when it will be seen that the parts in contact are congested and sticky. The discomfort frequently comes on only in the evening or after near work. In the gouty cases there may be œdema—*chemosis*.

Chemosis affects the most loosely attached parts of the conjunctiva, *i.e.*, principally the bulbar conjunctiva and fornices. The mucous membrane becomes swollen and gelatinous in appearance. The swollen membrane forms a wall around the cornea, which it may overhang in severe cases. The palpebral conjunctiva is little affected, but the tissues of the lid are often also œdematous, so that the lids are swollen and the upper hangs down over the lower.

Whenever watering of the eyes is complained of, and whenever only one eye is congested or shows signs of conjunctivitis, the lacrymal passages must be investigated. Pressure with the finger backwards and inwards over the lacrymal sac may cause regurgitation of fluid—tears, mucus, or pus—showing that the outflow into the nose is obstructed. If no regurgitation can be detected, the position of the lower punctum must be noted. It ought to be invisible until the lid is slightly everted.

The *treatment* of simple hyperæmia consists primarily in the removal of the cause. Defective conditions of life must be ameliorated if possible. The irritation of strong light must be removed, or modified by the use of dark glasses. ~~They should be chosen of the type which cuts off the actinic rays of the spectrum, *i.e.*, neutral tint ("smoked"), not blue.~~

Errors of refraction must be corrected. It should be remembered that the error may be artificial, through the use of wrong spectacles. The amount and conditions of near work should be specifically stated.

Defects of the lacrymal apparatus must be treated (Chap. XXX.). If no defect is noted, local treatment of the hyperæmia is ordered for a time; but if the condition does not improve, the patency of the lacrymal passages must be demonstrated by syringing. The beginner must be careful, however, that he does not do harm rather than good.

Errors of metabolism must be treated on general medical principles. Such causes are easily overlooked; hence they should be specially borne in mind.

Local treatment consists in bathing the eyes frequently with ~~hot~~ boric lotion, with or without a mild astringent, *e.g.*, zinc sulphate, gr. i. or ii. to ʒ i. A drop of a mixture of equal parts of tincture of opium and distilled water, night and morning, will be found soothing. Hazeline, 20 ♏ to ʒ i., is sometimes useful, but varies in its effect in different people. Cocain must be used with diffidence: its effects are transitory, and it has a deleterious action upon the corneal epithelium, but in quite weak doses often affords much comfort.

In cases where temporary alleviation—usually of the disfiguring signs—is insistently desired, a drop of adrenalin solution (1 in 1000) instilled into the eye will remove the discomfort and reduce the redness of

⑱

If the light is not very excessive ordinary neutral tinted (smoked?) glasses will suffice. They are better than blue or other coloured glasses as they reduce the intensity of the luminous rays almost uniformly throughout the spectrum. Hence, all glasses cut off a large percentage of the ultra violet rays, especially those of shortest wave-lengths. Sir William Crookes (kindly) has prepared a series of [illegible] glasses which have various absorptive powers. Some of these cut off practically all the infra red & ultra violet rays, whilst absorbing the luminous rays to a slight degree. Tinted Crookes's glasses are specially indicated for use in tropical climates.

the conjunctiva. The effect is, however, very transitory, but it will often earn gratitude. It is especially useful after the removal of a foreign body from the cornea.

The *nature of the secretion* in conjunctivitis is of diagnostic importance. It may be watery, mucous, muco-purulent, or purulent, and the disease is often classified accordingly. Most forms of acute conjunctivitis are due to bacterial agency. Unfortunately, each pathogenic organism does not produce a specific clinical picture. It is therefore wise in the meantime to retain the old clinical terminology.

Watery secretion is usually due to reflex secretion of tears. The other types of secretion show some relation to the bacterial cause, and must be distinguished on account of the information they convey as to the probable severity of the condition and the indication they provide for special measures of treatment.

The chief forms of conjunctivitis may be divided into two groups: acute, and sub-acute or chronic. Acute conjunctivitis may be classified as simple acute (including muco-purulent), purulent, membranous, and phlyctenular. Sub-acute or chronic conjunctivitis includes simple chronic conjunctivitis, angular conjunctivitis, follicular conjunctivitis, trachoma, tubercle, and syphilis.

Simple Acute Conjunctivitis (*Syn.—Catarrhal Conjunctivitis*).—The condition described as hyperæmia of the conjunctive passes imperceptibly into a condition characterised by greater and more general hyperæmia and a thicker mucous discharge which gums the lids together. The lids are usually described as being stuck together in the mornings, because the condition is most noticed after they have been closed for a considerable period. The causes, symptoms, and treatment are the same as in simple hyperæmia.

Various more intense forms of simple acute conjunctivitis are met with: they are probably all of bacterial origin, the organisms differing in different cases.

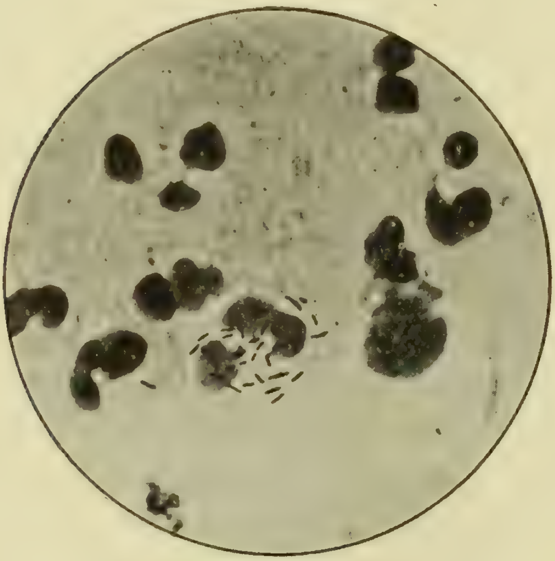


FIG. 92.—Koch-Weeks' bacilli (× 1000).

The commonest form is **Muco-purulent Conjunctivitis.** Here, as the name implies, the secretion is muco-purulent; it is more profuse than in the simpler forms. As in most cases of conjunctivitis the disease is contagious, being transmitted directly by the discharge and possibly by the air of ill-ventilated rooms, though this method is doubtful, since most of the organisms are non-sporing and are easily destroyed by drying. The whole conjunctiva is a fiery red ("pink eye"); all the conjunctival vessels are congested, except the circumcorneal zone in the milder cases (*vide* p. 95). Flakes of muco-pus are seen in the fornices, and often between and upon the margins of the lids. If the discharge is allowed to dry the lashes become matted together by dirty yellow crusts. These may be easily mistaken for the condition found in blepharitis, but if the crusts are bathed off the underlying lid margins will be found healthy. Flakes of mucus passing across the cornea often gives rise to coloured haloes, owing to their prismatic action. These "haloes" must be carefully distinguished from those met with in glaucoma (*q.v.*).

The discharge is at first mucous, but gradually becomes

(Among the lung diseases the disease so called "blight" which is commonly attributed to a "cold" or "chill". Cold probably acts only by lowering the resistance of the tissues to the action of organisms.

more purulent. Beginners are liable to mistake muco-purulent for true purulent conjunctivitis. In the former, the more purulent masses are found among the lashes and at the inner canthus, whilst the fornices and bulbar conjunctiva show only flakes of translucent or yellowish secretion. In the latter, crusts of inspissated pus may be seen among the lashes and at the canthi, but when the lids are separated fluid pus wells out.

The disease reaches its height in three or four days: if untreated it is liable to pass into a less intense, chronic condition. Complications are rare, but abrasions of the cornea are liable to become infected and to give rise to ulcers. Occasionally marginal ulcers form—in debilitated or old people, or as the result of improper treatment.

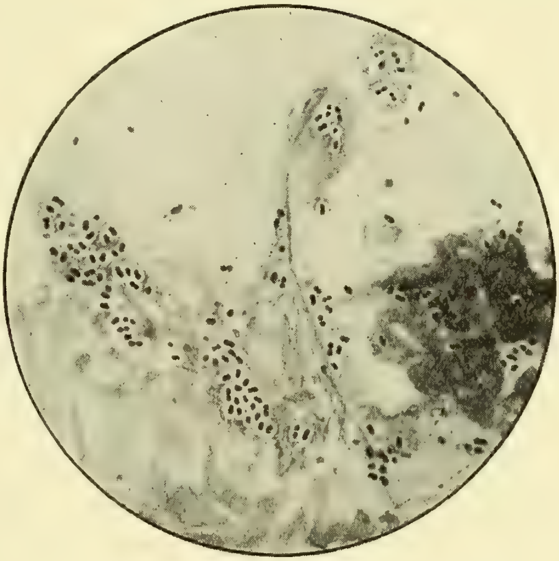


FIG. 93.—Pneumococci (× 1000).

Muco-purulent conjunctivitis frequently complicates phlyctenular conjunctivitis.

Pathology.—Muco-purulent conjunctivitis is frequently caused by the Koch-Weeks' bacillus (Fig. 92). This is a very slender rod, varying much in length. It stains badly with the ordinary basic dyes, *e.g.*, Löffler's methylene blue; it is decolourised by Gram. Groups of bacilli found in much degenerated, "skeletonised" pus cells are very characteristic.

The organism is rapidly destroyed by drying. It has been known to give rise to very definite epidemics. In England the cases are usually sporadic, though moderate transmission is common. An attack confers immunity for some time.

The Koch-Weeks' bacillus is by no means the only cause of muco-purulent conjunctivitis. Diplococci which are indistinguishable from pneumococci (Fig. 93) also cause it, probably more frequently in England. Pneumococcic conjunctivitis, though not definitely separable from the other acute forms clinically, shows distinct tendencies which should be borne in mind, the more so since the pneumococcus is the cause of hypopyon ulcer (*q.v.*). There is usually more œdema (chemosis), small ecchymoses are common, and a membranous film may form—"pseudo-membranous conjunctivitis." It is commonest in northern countries and in the cold weather, and is more often found in children than adults. It ends with a crisis, like pneumococcic infection of the lungs, after which the organism rapidly disappears from the secretion.

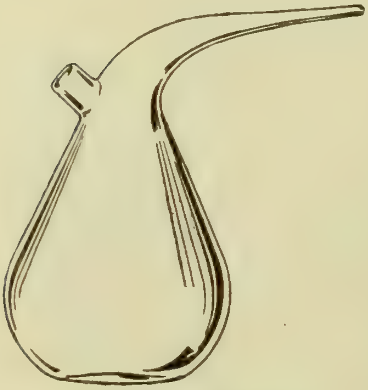


FIG. 94.—Undine.

The muco-purulent conjunctivitis associated with phlyctenular conjunctivitis is usually due to staphylococcus aureus, which may also set up conjunctivitis in cases of blepharitis and eczema or impetigo of the skin. This organism ~~also~~ sometimes causes a muco-purulent discharge after cataract extraction and other operations.

Other organisms have been found, but their ætiological relationship to the disease is not proved.

Treatment.—The best treatment for muco-purulent conjunctivitis is the frequent washing out of the conjunctival sac with lotio hydrargyri perchloridis (1 in 5000) (called hereafter sublimate lotion). It should be warmed and diluted by the addition of a little boiling water. The

This often accompanied by nasal catarrh, which may precede or follow the ocular inflammation. Iritis is very rare as a sequel of conjunctivitis but pneumococcic conjunctivitis is exceptional in this respect. The inflammation of the iris is set up by absorption of toxins (cf. Hypopyon Ulcer of the Cornea).

The influenza bacillus, which is distinguished with difficulty from the Koch-Weeks' bacillus, is responsible for conjunctivitis in influenza epidemics, more often ~~generally~~ in children than adults.

also

for the new born, probably owing to the defective resistance of the tissues in these conditions. In the presence of irritating dust a staphylococcic conjunctivitis of slight intensity may be set up. The presence of staphylococci is liable to aggravate conjunctivitis set up by some other organism.

or weaker/

Lists from Painting.

lotion must not be simply applied to the lids. It is well for the surgeon himself or a competent nurse to wash out the conjunctival sac the first time. For this purpose an "undine" (Fig. 94) is the most convenient reservoir. The lids are everted and the lotion is poured from a little height over the whole surface, every crevice being irrigated as thoroughly as possible. The nozzle of the undine should not be allowed to touch any part of the eye. The patient may be directed to use the ordinary eye-bath for the application of eye lotions. If a child, the parents should be instructed to hold the lids apart, the child lying upon its back. A pad of cotton wool, dripping with the lotion, which may be warmed, is then held over the eye and the lotion squeezed out: the process is repeated until all discharge has been washed away. The lotion may be warmed by placing the bottle in hot water, but the addition of an equal part of hot water suffices; eye lotions act chiefly by washing out deleterious material, since they cannot be used sufficiently strong to act as efficient antiseptics. For this reason boric acid lotion is probably nearly as efficacious.

Boric acid ointment or sterile vaseline is smeared along the lids at bed-time, or, in children, as often as they are put to sleep: it prevents the lids from sticking together —a two-fold benefit, that of obviating pain on opening them, and that of preventing discharge from being retained.

The eyes should never be bandaged, as it prevents the free exit of the secretion. If there is any photophobia a shade or dark goggles should be worn. The patient should spend as much time out of doors as possible.

If this treatment is properly carried out, the patient will be well in a few days. Even if only partially successful there will then be less discharge.

If the case is not progressing as rapidly as could be desired, or the attendants are not reliable, and if the discharge is subsiding, it is wise to paint the lids once with silver nitrate solution (gr. x. to ℥ i.). This is the strength which should always be used for painting lids. Stronger solutions act too vigorously as caustics, and if a caustic effect is desired, it can be obtained with greater precision by other means. Weaker solutions are precipitated by the chlorides in the lacrymal secretion, so that they are practically useless.

The following is the best method of painting lids. A glass rod is used, tapering at each end (Fig. 95). The finger should be passed over the ends each time before use to make sure that they are not chipped. The end is dipped in lotion to damp it. A *very thin* wisp of cotton wool is then tightly wound round the end, starting where it begins to taper: this fixes the wool. The end of the wisp is left loose, so that it may absorb the solution. The other end of the rod is armed in the same manner.

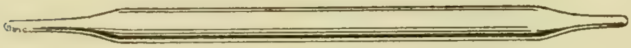


FIG. 95.—Glass rod.

The patient, if a child, is placed upon its back. The lids are everted; the wool, dipped in the silver solution, is applied freely to the conjunctival sac, the cornea being protected as much as possible. It is quite unnecessary to neutralise the excess of nitrate with salt solution, as is often taught. The excess may be mopped up with a pad of dry absorbent wool. If, as is usually the case, the other eye is affected, the other end of the rod is used in the same manner. In the absence of a glass rod the best implement is an ordinary wooden match, used in the same way. The match can be thrown away after use. The glass rod must be sterilised by boiling. A camel's hair brush should not be used: it cannot be kept aseptic.

(22) Silver nitrate acts by forming a thin ~~[illegible]~~ epithelial eschar & coagulating the mucopurulent discharge. The bluish white film ~~which~~ is cast off in flakes, & till this process is complete the feeling of a foreign body is [illegible] experienced. Silver nitrate is not strongly bactericidal, but the organisms are entangled in the coagulum & removed with it. Moreover there is a powerful physiological response to the caustic; hyperaemia occurs & the tissues are flooded with blood serum, which can then more effectively exert its bactericidal & antitoxic powers. The slightly greater efficacy of protargol & the newer substitutes for silver nitrate is to be attributed to their smaller caustic & irritant properties which are ~~[illegible]~~ regarded as their chief advantages.

(23) ¶ Since the discharge of gonorrhoeal cases [illegible] must be taken to prevent its spread. The patient must be cautioned to wash his hands, cleanse & [illegible]; no one else must be allowed to use his towel, handkerchief, &c.

A single painting with silver nitrate will often produce an excellent result. It is good as a prophylactic if discharge is inadvertently introduced into a normal eye. Other preparations of silver—protargol (20 per cent.), argyrol (25 per cent.), &c.—are not so efficacious, but they have the advantage of being less painful.

The conjunctiva generally returns to a perfectly normal condition. If the case has been neglected and chronic inflammatory signs persist, astringents should be used as for chronic conjunctivitis (*q.v.*).

Purulent Conjunctivitis (*Syn.—Acute Blennorrhœa, Gonorrhœal Conjunctivitis*) is a much more serious condition. It occurs in two forms—as ophthalmia neonatorum in babies, and as gonorrhœal conjunctivitis in the adult. Certainly the former, and probably the latter, is not invariably gonorrhœal.

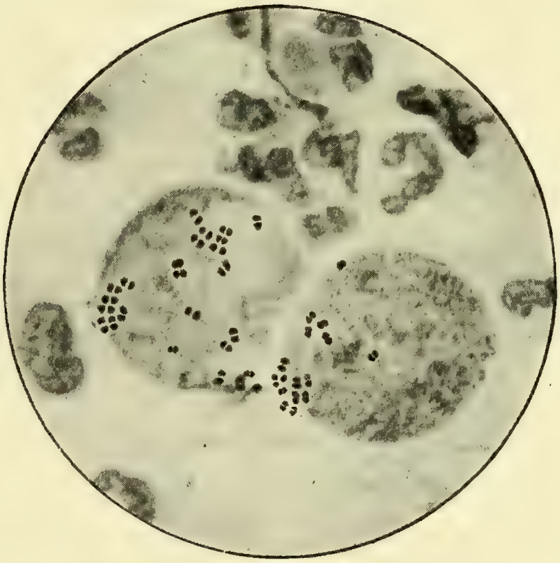


FIG. 96.—Gonococci (× 1000).

Gonorrhœal Conjunctivitis (*Syn.—Acute Blennorrhœa of Adults, &c.*).—Gonorrhœal conjunctivitis is even more serious in the adult than in babies; fortunately, considering the prevalence of gonorrhœa, it is comparatively rare. Whilst generally due to the gonococcus it is important from the medico-legal point of view to remember that the same features may be found with streptococci, diphtheria, and probably mixed infections. The gonococcus is a bun-shaped diplococcus, staining readily, decolourised by Gram, and found within both leucocytes and epithelial cells (Fig. 96). The micrococcus catarrhalis and the meningococcus, both Gram-negative, are sometimes found in the conjunctival sac. They may be distinguished from the gonococcus by the ease with which cultures are obtained and by agglutination tests.

The disease is due to direct infection from the genitals. Males suffer most, the right eye before the left in a right-handed person. There is more swelling of the lids and conjunctiva than in children, copious purulent discharge, more tendency to involvement of the cornea, and marked constitutional disturbance—rise of temperature, and so on, but especially very marked depression of spirits. The greater danger to the cornea is due to the chemosis, which produces blood and lymph stasis and facilitates the retention of secretion.

The incubation period is a few hours to three days. The upper lid becomes enormously swollen and tense, overhanging the lower, and edged with pus. Eversion, which is difficult, shows that the palpebral conjunctiva is deep red and velvety : rarely there is a membrane. Occasionally the discharge is sanious rather than purulent, especially in streptococcic cases. There is great pain ; the preauricular gland is enlarged and tender, and may suppurate.

After two or three weeks the purulent discharge diminishes, but subacute conjunctivitis persists for several weeks longer. The gonococcus is still present—a point of great importance, both as regards contagion and treatment.

The most important point in diagnosis is the coincidence of urethritis. The most important point in prognosis is the condition of the other eye.

Corneal complications are the rule, and constitute the causes of blindness. There may be diffuse haziness of the whole cornea, with grey or yellow spots near the centre. Ulcers may occur at any part, and are due to necrosis of the epithelium through direct invasion by the organisms.

The micrococcus catarrhalis has not yet been found in acute conjunctivitis, but only in chronic & post-operative forms.

~~The preauricular gland is enlarged.~~

with much papillary thickening of the conjunctiva.

No immunity is conferred by the attack.

Marginal ulceration, which may extend completely round the cornea, is due to retention of pus in the angle formed by the chemotic conjunctiva. When ulceration has commenced it progresses rapidly and deeply, since the tissues are bereft of their first line of defence—the epithelium. Perforation is therefore common, with all its attendant dangers (*vide* p. 228). Ulceration commencing late in the history is not so dangerous.

The greatest care should be taken to prevent injury to the cornea during the manipulation necessary for diagnosis and treatment. Abrasions are easily produced by the finger nails, and even by the rough use of wool swabs. Such abrasions rapidly become dangerous ulcers.

Treatment must be directed first to protection of the other eye. This is at once sealed up with a Buller's shield, which consists of a watch-glass stuck in a frame of adhesive plaster, or better, rubber (Fig. 97). The rubber is hermetically sealed down to the face and nose except at the lower outer angle, where a small piece of tubing is inserted under the edge. If this means of ventilation is not adopted the glass becomes hazy and the eye cannot be properly observed ; moreover, the irritation to the eye is greater. Special attention should be directed to fixing the shield near the nose, *i.e.*, on the side of the source of infection. Patients should be told to sleep lying on the same side as the affected eye.

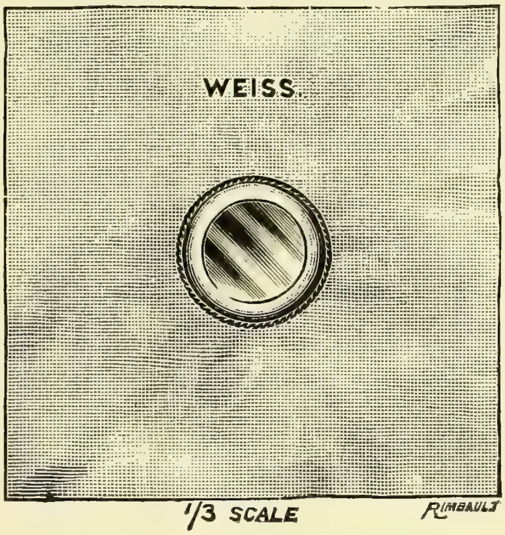


FIG. 97.—Buller's shield.

If the second eye should show signs of infection it must be treated, but every utensil or dressing which is applied to the eye must belong to a totally different set from that used for the worse eye, otherwise it may be inoculated rather than treated. The less affected eye must always be dressed first.

If pus from a gonorrhœal conjunctivitis spurts into the surgeon's eye, the conjunctival sac should be freely irrigated with sublimate lotion and the lids painted once with silver nitrate (*vide* p. 180). The eye should be carefully watched, but no further drastic treatment applied unless conjunctivitis supervenes. The accident is due to carelessness, for every attendant on a gonorrhœal case should wear protective goggles.

If the disease is fully established and there is abundant purulent discharge, the eye must be irrigated every two hours during the day and every four hours during the night with warm boric or weak sublimate lotion (1 in 8000). Iced wet dressings are applied in the intervals, but are to be bandaged on quite loosely, so as to avoid retention of discharge. The patient is kept in bed, and if intelligent, can bathe his lids in iced lotion in the intervals. Iced applications afford much relief to the patient, though hot ones are probably more efficacious.

Most reliance must be placed on applications of silver nitrate, but they must be used with discretion. When not contraindicated the conjunctiva of the everted lids should be well painted with silver nitrate, gr. x. to ℥ i., not oftener than once a day. Special care must be taken to avoid injury (*vide* p. 103). This treatment is contraindicated in the very early stage before free discharge has set in, and also in later stages if there is much brawny swelling with comparatively little discharge. Under these conditions the stasis is so great that reaction is inefficient; the caustic, in fact, induces the necrois which it should be our endeavour to avoid. In such cases hot applications and

(0.85%, NaCl),
~~Ringer's solution~~ a simple saline ~~bath~~ or a sea [illegible]
~~produced by~~ [illegible]

/ Römer observed passive immunization by means of the local application of a specific gonococcus serum. It may be injected into the conjunctival sac or used as a 1 per cent solution in 0.85 per cent sodium chloride for irrigation. [illegible] as general immunity is conferred by the ~~[illegible]~~ organism active immunization with a gonococcus vaccine is [illegible].

Ital. / Metastatic Gonorrheal Conjunctivitis sometimes occurs in adults, associated with gonorrheal arthritis. It is a mild simple conjunctivitis, occasionally ~~[illegible]~~ accompanied by iritis. It is probably due to endogenous infection from gonococci in the blood. It usually responds readily to local treatment, but is apt to recur if the arthritis relapses.

leeches should be relied upon. The latter are applied over the temporal region near the outer canthus. If the lids are very tight the outer canthus should be split (canthoplasty). The ends of strong blunt-pointed scissors are inserted between the lids into the angle under the outer canthus, which is then divided by a single snip in a horizontal direction. This has the good effect of bleeding the patient slightly, and also of giving free exit to discharge.

Scarification of the chemosed conjunctiva has been recommended and may be done. The removal of the ring of conjunctiva which overhangs the cornea is good, but demands cocain, which has a bad effect on the corneal epithelium. Mercury, by inunction or small doses of calomel, is said to diminish the chemosis.

It is of great importance to attend to the general health. The bowels must be kept freely open. The strength must be reinforced by every available means—good food, tonics, alcohol if necessary. An occasional sleeping draught and the use of sedatives must be ordered according to general principles. Every effort must be made to combat the depression from which these patients suffer.

In the final stage of the disease silver nitrate should be used at increasing intervals for a week or fortnight after the purulent discharge has ceased. Astringent lotions are then employed (*vide* p. 197).

Corneal complications require very active treatment (*vide* pp. 231, *sqq.*).

Ophthalmia neonatorum is a preventable disease occurring in new-born children as the result of carelessness at the time of birth; it is responsible for a large proportion (10 per cent., Fuchs) of all blind people. It is due to infection by vaginal or fæcal matter, or from dirty rags used to clean the eyes. Purulent discharge is usually noticed on the third day; when it occurs later it is generally due to post-partum infection. Both eyes are usually affected. The conjunctiva is intensely inflamed, bright red, swollen, and pouring out thick, yellow pus. Marked chemosis is a distinguishing feature from severe muco-purulent conjunctivitis.

There is great risk of corneal ulceration in ophthalmia neonatorum, especially, as is usually the case, when it is due to the gonococcus, which has the power of invading intact epithelium. Often the cornea is already ulcerated, and not infrequently perforated, when the child comes under observation. Ulceration usually occurs over an oval area just below the centre of the cornea, corresponding with the position of the lid margins when the eyes are closed and consequently rotated upwards somewhat. More rarely marginal ulcers are formed as in the gonorrhœal conjunctivitis of adults.

Metastatic arthritis occurs rarely, as in gonorrhœal urethritis.

The baby's eyes must be examined as described in method (4), p. 93. The surgeon must wear protective goggles lest pus spurt into his eyes when the child's lids are separated.

Pathology.—Probably 60—70 per cent. of cases are due to the gonococcus; the Bac. coli is responsible for some of the remainder, probably through fæcal infection, streptococci for others. Streptococcic conjunctivitis is even more virulent than gonococcic, the cornea being in imminent danger. A film should be taken from every case.

Treatment.—The disease is preventable; *prophylactic* treatment is therefore of prime importance. The new-born baby's closed lids should be thoroughly cleansed and dried. The lids are then separated, and a drop of silver nitrate solution, gr. x. to ℥ i., instilled into each eye (Credé's method). The eyes must be carefully watched during the first week.

If the disease is established the eyes must be irrigated

Stomatitis &

The arthritic ~~inflammatory~~ manifestations usually appear in the third or fourth week & affect the knee, whilst, ankle & [illegible] elbows. The course is benign, abscesses being rare.

[illegible] with impetigo.

Saline or [illegible]

every two hours with ~~sublimate~~ lotion, and the lids painted once daily with silver nitrate. The surgeon must wear protective goggles. The slightest sign of corneal haziness is an indication for the use of atropin, 0·5 per cent. (*vide* p 231). The use of antigonococcic serum has been advocated.

Membranous Conjunctivitis (*Syn.—Diphtheritic Conjunctivitis*).—As in inflammation of the throat the surface may become covered by a fibrinous membrane, so the same may occur in the conjunctiva; and just as the milder clinical varieties in the former were distinguished as croupous from the severer or diphtheritic, so also with conjunctivitis. It has been placed beyond dispute, however, that mild cases may be diphtheritic, and severe non-diphtheritic; hence it is best to speak simply of membranous conjunctivitis until a bacteriological examination has placed the matter beyond dispute. A variety of organisms other than the diphtheria bacillus, *e.g.*, pneumococcus, streptococcus, can produce a membrane, especially in weakly children, *e.g.*, after measles; these cases are sometimes called pseudo-membranous. They cannot be distinguished clinically with certainty.

Membranous conjunctivitis occurs chiefly in children, and shows all degrees of severity; it may be as virulent as the worst cases of gonorrhœal ophthalmia. It is uncommon in England, but it is of the utmost importance that it should be recognised when seen, not only on account of the grave danger to the eye but also from the risks of contagion.

In mild cases there is some swelling of the lids and a muco-purulent or sanious discharge. On everting the lids the palpebral conjunctiva is seen to be covered with a white membrane, which peels off readily without much bleeding.

In severe cases the lids are more brawny: the conjunctiva is permeated with semi-solid exudates, which impair the mobility, compress the vessels, prevent the formation of a free discharge, and tend to necrosis both of the conjunctiva and cornea. Here the membrane separates much less readily, the underlying surface bleeding unless it is too infiltrated and solid. The membrane may be patchy or cover the whole palpebral conjunctiva, often beginning at the edge of the lid. It is seldom found on the ocular conjunctiva. The preauricular gland may be enlarged and may suppurate. The temperature is raised, unless the patient is in a moribund condition. Albumin is frequently present in the urine.

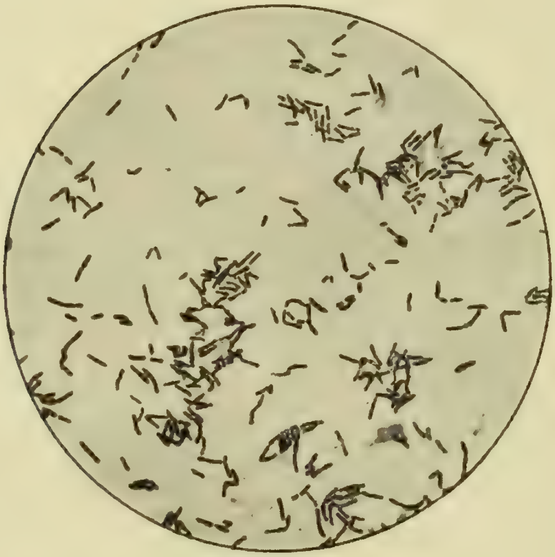


FIG. 98.—Diphtheria bacilli (× 1000).

For six to ten days there is great peril to the cornea. Then the sloughs begin to separate and the discharge becomes more profuse. In a few days the conjunctiva assumes a red and succulent appearance. There is danger now of adhesions forming between the palpebral and bulbar parts of the conjunctiva (symblepharon).

Post-diphtheritic paralysis, even of accommodation, is rare.

Cases of less severe but more chronic membranous conjunctivitis are occasionally met with. In them the membrane is cast off, but occurs again and again. The pathology of these cases is not understood.

Pathology.—Competent bacteriologists have shown that there is little or no relationship between the severity of

(The pseudo-diphtheria bacillus forms little or no acid in culture. It is not virulent for guinea pigs, the difference in virulence can be determined by agglutination tests. Neisser's stain (acetic methylene blue + Bismarck brown) demonstrates blue granules at the poles of the diphtheria bacillus in cultures of 24 hours. None but virulence tests are absolutely reliable.

(Staphylococcus, Friedländer's pneumonia bacillus, bacterium coli, the local condition and the presence or absence of the Klebs-Löffler bacillus (Fig. 98). Only series of cases in which positive results have followed inoculation into animals are absolutely trustworthy, owing to the difficulty of distinguishing the diphtheria from the xerosis bacillus, with which it is morphologically identical.

Other cases may be due to the action of heat, caustics, severe atropin irritation, herpes iris, and other non-bacterial causes. Other bacteria which occasionally form membranes are streptococcus, Koch-Weeks' bacillus, gonococcus, pneumococcus, &c.

It is quite rare to obtain evidence of primary diphtheria of the throat, though the disease may have been derived from a case of faucial diphtheria, and extension to the nose and throat by way of the lacrymal sac and nasal duct occurs. The genitalia should be examined for diphtheria or leucorrhœic discharge.

Treatment.—Every case should be treated as diphtherial unless good negative evidence is afforded by films and serum cultures. In mild cases isolation need not be strict until the bacteriological report is obtained on the second day.

The treatment is essentially that of purulent ophthalmia, with one important exception, viz., that painting with nitrate of silver is not to be resorted to. Further, canthoplasty is not to be done, since both these procedures increase the area from which toxins may be absorbed.

Local treatment consists of hot irrigations and bathings as for purulent ophthalmia (*q.v.*). One drop of atropin should be instilled at the commencement of treatment. Quinine lotion, gr. iii. to ℥ i., with a minimum of acid to dissolve the salt, has been recommended.

The most important general treatment is the administration of antitoxin as in faucial diphtheria. Since the antitoxin is innocuous it should be used at once in every doubtful case. I have obtained benefit by local instillations of antitoxin, which is a rational procedure but seems to have been neglected. Special attention should be paid to the nutrition, and tonics are indicated.

Corneal complications must be suitably treated (*vide* p. 231).

Phlyctenular Conjunctivitis (*Syn.—Eczematous Conjunctivitis*).—In phlyctenular conjunctivitis (Plate IV., Fig. 1) one or more small, round, grey or yellow nodules, slightly raised above the surface, are seen on the bulbar conjunctiva, generally at or near the limbus; they rarely occur on the palpebral conjunctiva. The disease is very frequently complicated with muco-purulent conjunctivitis, in which case the whole conjunctiva is intensely reddened. In pure phlyctenular conjunctivitis the congestion of the vessels is limited to the area around the phlyctens.

The disease is most frequent in children from five or six to ten or twelve years of age, but not very young children; it is rarely seen in adults. The children often have enlarged lymphatic glands in the neck, &c., or other signs of tubercle; on the other hand every sign of tubercle may not infrequently be lacking: the children, however, are seldom robust. The first attack often follows an exanthem, especially measles. Rhinitis and adenoids are frequently present; signs of congential syphilis may be found.

Phlyctens, as the name suggests (φλύκταινα, a bleb), at first much resemble blebs: it is doubtful, however, whether there is a true vesicular stage. They may be so small as to be seen with difficulty, but they usually measure about 1 mm. in diameter, occasionally reaching a diameter of 3 mm. or 4 mm. The larger ones are yellow, and have been described as pustules. In the later stages the epithelium over the surface is often destroyed, small ulcers being formed. When this occurs on the conjunctiva proper h Antitoxins are specific, in effect as may be shown by experiment. If ~~the cornea of two rabbits are inoculated with diphtheria~~ ~~toxin~~ diphtheria toxin is injected into the cornea of two rabbits & one is given an intravenous injection of antitoxin the cornea of this ~~latter~~ animal will remain clear, whereas that of the other will become cloudy. Corneal ulceration, however, is usually due to secondary infection with pyogenic organisms. It may start at the middle or margin of the cornea & is not wholly due to interference with nutrition.

In streptococcic membranous conjunctivitis the danger of necrosis of the cornea & even of the death of the patient is so great that immediate recourse should be had to an injection of antistreptococcic serum.

h Eczema of the skin, especially in children, is frequently associated with [illegible] eczema in face is often regarded as a [illegible] of eczema of the conjunctiva.

PLATE IV.

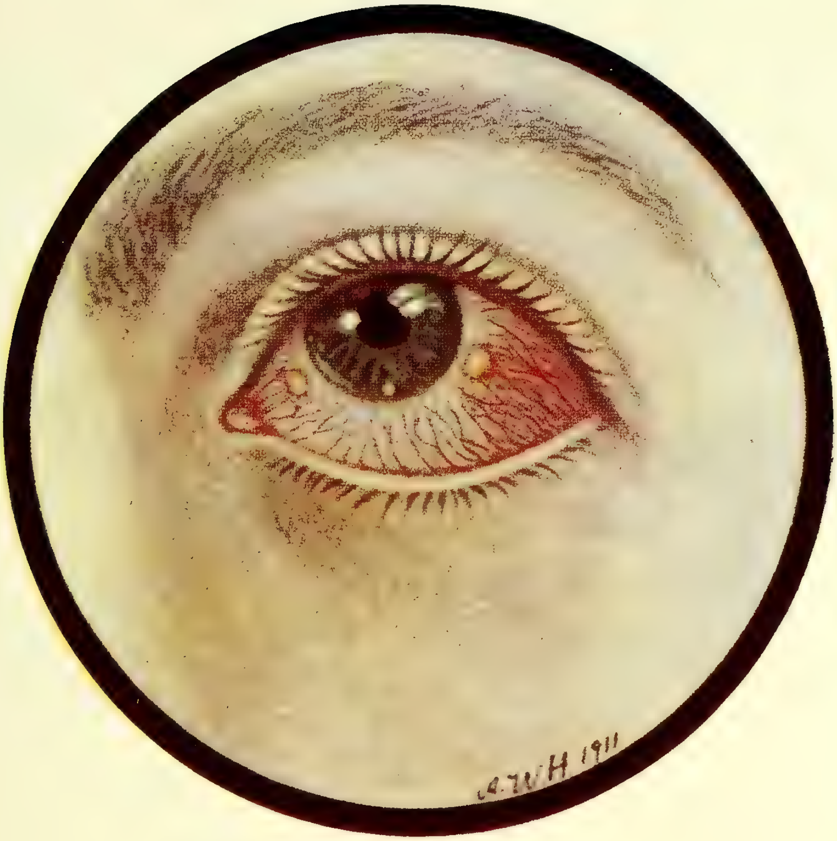


FIG. 1.

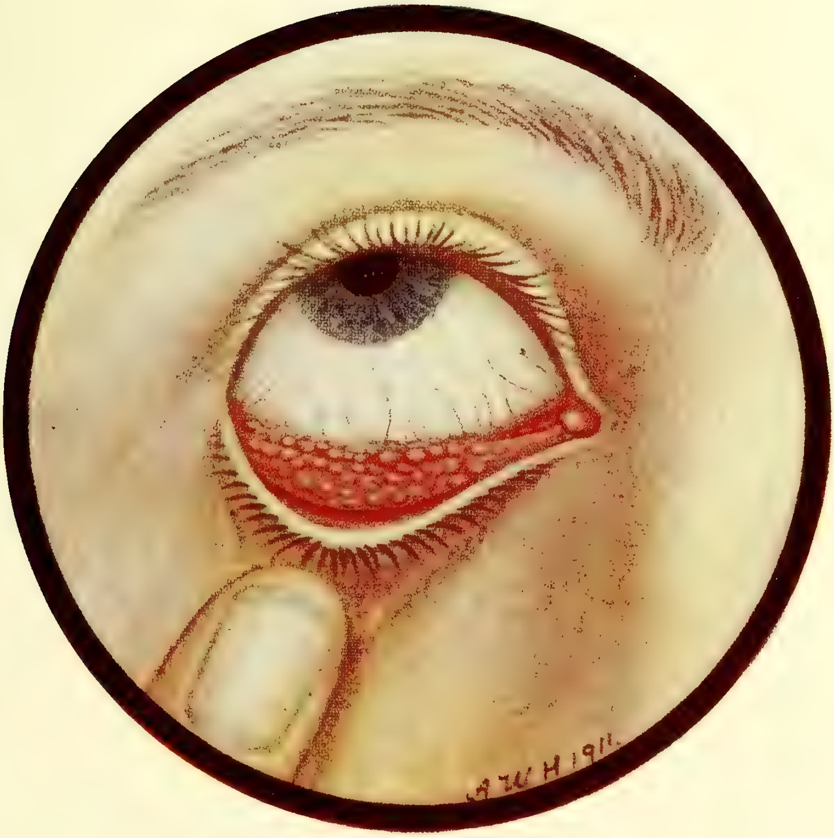


FIG. 2.

[Apparently in the Script]

Fragmented]

it is of little moment, since healing takes place rapidly without the formation of a scar. When it occurs on the cornea, as is very frequently the case, it is much more serious (*vide* p. 249).

Very frequently the skin of the lids and cheeks shows an eczematous condition, and eczema will be found not uncommon, if searched for, in other parts of the body. This fact has led the condition to be regarded by some as an ocular manifestation of eczema. The disease has indeed been regarded as an exanthem. It is probable that in most cases the eczema of the lids and face is secondary to the continual irritation of the skin induced by the overflow of tears and the rubbing of the wet surface with the hands.

Pathology throws some light on the disorder, though it by no means settles the causation. A simple phlycten shows in section a triangular area of intense infiltration, the apex of the triangle being towards the deeper layers. The sub-epithelial adenoid layer normally contains a few mononuclear lymphocytes, but in the phlycten they are very numerous and closely packed together. The epithelium is intact, and it is doubtful if a vesicular stage has ever been observed.

If there is a considerable amount of conjunctivitis of the muco-purulent type, not only are lymphocytes present but there are also many polymorphonuclear leucocytes, both in the sub-epithelial tissues and amongst the epithelial cells. In such cases the epithelium is quickly destroyed.

If a bacteriological examination is made, many of the organisms of muco-purulent conjunctivitis may be found. In the pure phlyctenular cases only staphylococci are found in abundance. Now staphylococci are not so common as might be expected in the normal conjunctival sac; it has, therefore, been concluded that the disease is due to staphylococcic infection. If staphylococci are rubbed into a healthy or excoriated conjunctiva a transitory redness occurs and rapidly passes off. Phlyctens have never been produced in this manner. The nearest approach to the artificial production of phlyctens has been by injecting cultures of tubercle bacilli, in which the organisms have been killed, into the veins of rabbits. It is doubtful if the infiltrates were real phlyctens in these experiments, but it is certain that the administration of tuberculin has not infrequently been followed by an attack of phlyctenular conjunctivitis in the human subject.

We are now in a position to judge more accurately what probably occurs in phlyctenular ophthalmia. It is not improbable that the true cause of the outbreak is a toxæmia, the toxins—probably tuberculous—not being very potent, but sufficient if the patient is already in a weakened condition. The irritation of the eye leads the child to rub it vigorously. The lacrymation and rubbing cause an eczematous condition of the skin, in which the staphylococci normally present flourish and increase. These are rubbed into the eye, increasing the irritation, without being primarily responsible for the disease. Other organisms are also rubbed in if they happen to be present ; they find a suitable nidus in the debilitated conjunctiva, and an acute muco-purulent conjunctivitis is superposed upon the phlyctenular disease.

Simple phlyctenular conjunctivitis is attended with few symptoms. There is some discomfort and irritation associated with reflex lacrymation. If there is no muco-purulent complication and if the cornea is not involved there is little or no photophobia.

Complications, however, are the rule, partly because the behaviour of the child conduces to them, partly because the favourite situation for the phlyctens is near the cornea. Here they are often astride the limbus. It has already been mentioned that the epithelium of the cornea is closely associated anatomically and developmentally with the k On the other hand the superficial position of the lesions & the similarity to other ulcerative conditions of the cornea favour the view that the disease is ectogenous in origin, the exciting agent being at present unknown.

conjunctiva. It is not surprising therefore that there is a great tendency for the superficial layers of the cornea to suffer when the conjunctiva is disordered, and this is seen par excellence in phlyctenular ophthalmia. The special corneal complications will be considered later (*vide* p. 249). In all such cases lacrymation is increased, muco-purulent discharge is often present, and photophobia is intense.

The term photophobia (φῶς, light; φόβος, fear; dread of light) is a misnomer. It is the term applied to the blepharospasm which is set up by the conjunctival, or more probably corneal, irritation, and which becomes greatly increased on the slightest attempt to separate the lids, especially if the attempt is made in bright light. This blepharospasm is not abolished in the dark; it is abolished by thorough application of cocain, though this is difficult to effect. It must be concluded therefore that it is a reflex due to afferent impulses travelling along the fifth nerve, not along the optic nerve. It has been said that light acts as the stimulus to the fifth nerve endings in the cornea. This conjecture must be regarded as a survival of the old fallacy. There is no evidence to prove—though it is not disproved—that light can stimulate the fifth nerve endings. It is far more probable that "photophobia" is due to a vicious circle of such a nature that movement of the lid over a spot denuded of epithelium, where the nerve endings are laid bare, causes reflex contraction of the orbicularis; this increases the irritation, increasing in turn the blepharospasm.

Photophobia is more intense when the phlyctens are near the cornea, than when at a distance. It varies rather with their number than their size, and is extreme if they are so numerous as to form a ring round the cornea.

Temporary blindness has been observed occasionally in children after long-continued blepharospasm. It passes off in two or three weeks and is probably functional, induced primarily by the desire not to see and facilitated by the effect of prolonged pressure upon the globe by the tightly closed lids.

Severe blepharospasm makes the greatest care in the first examination imperative. The condition of the cornea is in all cases and at all costs to be placed beyond doubt. It facilitates investigation if the lids are gently separated and a drop of 2 per cent. cocain instilled. The child is left for 5 to 10 minutes and the eyes are then examined with all the precautions described above (p. 103).

Phlyctenular conjunctivitis shows a very marked tendency to recur at intervals during the age period which is specially concerned. These recurrences usually take place when some intercurrent malady or defective condition in the patient's surroundings leads to lowering of vitality.

Treatment.—Simple phlyctenular conjunctivitis is usually readily amenable to treatment, which must be local and general.

Local treatment consists in bathing the eyes frequently with hot boric or sublimate lotion: yellow oxide of mercury ointment, gr. iv. to viii. to ℥ i., is used, a piece the size of a hemp seed being placed within the lids three times a day; the eye is gently massaged by a finger placed upon the upper lid, moving the lid upon the globe.

Ointments are best applied on a glass rod. The child is placed upon its back on a couch and an assistant holds the arms against the body, keeping the legs still by pressure with the elbows. The surgeon separates the lids with two fingers of one hand and places the end of the glass rod carrying the ointment between the separated lids. Keeping the rod in position the lids are allowed to close upon its end, and it is then withdrawn by carrying it outwards towards the temple. The other end of the rod and the surgeon's other hand are used for the other eye.

([illegible] 0.3, [illegible] 0.2, [illegible] 2.0, [illegible] 0.6)
[illegible]

If there is any corneal complication, or evidence of its imminence, atropin, gr. iv. to ℥ i., is combined with the yellow ointment.

Very frequently the soddening of the skin with tears and the wrinkling of the skin through blepharospasm cause excoriations (rhagadæ) at the outer canthus. They much increase the blepharospasm and should always be looked for and treated. They are very troublesome unless attacked by cauterisation. They should be touched with the sharp point of the solid silver nitrate or the mitigated silver stick.

An efficient substitute for the yellow oxide which has fallen into undeserved disuse is finely powdered calomel, dusted into the eye, best from a camel's hair brush, which is not allowed to touch the eye. It often produces a remarkable improvement in intractable cases, but it must not be employed if iodides are being given internally; under these circumstances the unstable and extremely irritating mercurous iodide is formed in the conjunctival sac.

The photophobia is best treated, when severe, in the following manner. The child's face should be plunged in cold water and the mouth and nose kept under water until he struggles for breath: this is repeated three or four times—daily if necessary. The treatment is useless if not carried out ruthlessly, but no other method is so efficacious. It is not uncommon for a single application to render further treatment of the photophobia unnecessary.

The eyes are not to be bandaged unless corneal ulceration is so severe as to assume the preponderant *rôle*. A shade, covering both eyes and extending well over the temples, should be ordered. Smoked glasses may be substituted, but they should not be tightly fitting goggles, which will become soiled with the discharge and are cleaned with difficulty.

General treatment is never to be neglected, otherwise recurrence is inevitable. Fresh air is the best tonic, and the children should be kept out of doors as much as possible: the windows of living and sleeping rooms must be kept open. Cold or sea-baths are useful. Good food, with a plentiful supply of fresh vegetables, is indicated. A calomel purge should initiate the general régime.

Cod liver oil and maltine are given in the cool weather and throughout the year if well tolerated. Phosphates and iodide of iron form substitutes or supplementary tonics.

General régime must be continued for a prolonged period in order to prevent recurrence, and in any case, phlyctenular ophthalmia should be regarded as a sign of debility which requires attention.

Simple Chronic Conjunctivitis occurs as a continuation of simple acute conjunctivitis, sometimes in spite of orthodox treatment, especially in the "gouty" type of patient. It is frequent when the cause of irritation is continuous—smoke, dust, heat, bad air, late hours, abuse of alcohol, and so on. A very common cause is the chronic reflex irritation induced by errors of refraction, overuse of the eyes in bright electric light, &c. Permanent irritation from concretions (*vide* p. 213) in the palpebral conjunctiva, misplaced lashes, dacryocystitis, chronic rhinitis, &c., must be remembered and as far as possible eliminated. It is often necessary to make a thorough and systematic investigation of the local and general conditions before the cause can be found. The disease is too frequently regarded as trivial, but it is a source of great discomfort to the patient, who is duly grateful for permanent relief.

Burning and grittiness are complained of, especially in the evening, when the eyes often become red. Difficulty in keeping the eyes open is a common symptom. The lids may or may not be stuck together on waking.

Unilateral chronic conjunctivitis should suggest the presence of a foreign body retained in the fornix or a dacryocystitis.

h It is not infrequently associated with chronic intranasal troubles.

h. of chronic nasal catarrh

1 A greatly hardened, which can be loosened by an application with pepsine.

1 Ichthyol combined in using [illegible] massage with a zinc ichthyol ointment is useful (ammon. ichthyol 0.15, zinc oxide 5.0, vaselin. alb. 15 (Unna)).

The discharge is slight, most frequently subnormal, so that the edges of the lids feel hot and dry.

The eyes may look quite normal on first examination. When the lower lid is pulled down the posterior conjunctival vessels are seen to be congested, and the surface of the mucous membrane is sticky. The palpebral conjunctiva, upper and lower, may be congested, with velvety papilliform roughness. Occasionally it is succulent and fleshy.

Treatment consists in eliminating the cause and restoring the conjunctiva to its normal condition. Errors of refraction are perhaps most likely to be forgotten; they should be sought out as a matter of routine. When heat is a prominent ætiological factor, *e.g.*, in cooks, spectrum blue glasses may be ordered, since they cut off the heat rays to a large extent. The treatment of the special local conditions mentioned above will be discussed in their proper place.

Local treatment consists essentially in diminishing congestion and restoring the conjunctiva to its normal suppleness and secretory activity. It must be remembered that the condition is largely one of lack of tone, due to defective response to prolonged irritation. A stimulating treatment is therefore indicated, and is supplied by astringent applications, which not only act by relieving the congestion, but also promote a more healthy lymph flow and glandular secretion.

In mild cases weak astringent lotions suffice, *e.g.*, boric lotion with zinc sulphate, gr. ii. to ℥ i., alum lotion, gr. iv. to ℥ i., &c. They should be used two or three times a day, not immediately before going to bed. Adrenalin has a transient effect in diminishing redness and itching. Boric acid ointment or sterile vaseline should be applied to the margins of the lids at bed-time.

In severer cases a preliminary painting with silver nitrate solution is indicated, repeated once or twice a week if necessary. Silver preparations should not be ordered for application at home, since prolonged use may lead to staining of the conjunctiva (argyrosis).

Atropin, which is always resorted to by the inexperienced in intractable diseases of the eye, does much more harm than good. It causes great inconvenience from paralysis of accommodation, and has little effect upon the conjunctiva, such as it has being deleterious. Apart from this, it is extremely dangerous in elderly patients, who are specially liable to chronic conjunctivitis. In them, more than in others, there is grave danger that atropin may induce an acute attack of glaucoma, a disaster which it is impossible to overrate.

In the more severe cases of chronic conjunctivitis there is often an abnormal amount of secretion from the Meibomian glands. It should be squeezed out of the glands by pressure on the lid with the thumb against a glass rod laid upon the conjunctival surface.

Angular Conjunctivitis (*Syn.—Diplobacillary Conjunctivitis*) is one of the few forms in which a specific organism causes a typical clinical picture. In it the reddening of the conjunctiva is limited almost exclusively to the intermarginal strip, especially at the inner and outer canthi, and to the bulbar conjunctiva in the same neighbourhood. Besides the conjunctivitis there is also excoriation of the skin at the inner and outer angles, which may be very slight, a mere scurfiness, but is nearly always present. After a few cases have been seen the typical picture is very easy to recognise, but the condition is not always typical. There is discomfort, with slight muco-purulent discharge ; blinking is often complained of. If untreated the condition becomes chronic and may give rise to definite blepharitis. Clear, shallow corneal ulcers may occur, but are rare.

or the milder protargol (~~5~~ 5-10 %) may be used.

They are usually marginal, but may be central & associated with hypopyon (?).

~~If untreated a severe blepharitis may be set up~~ – A single attack does not
confer immunity & relapses are not uncommon.

h The diplobacilli are strongly resistant to drying. They have been found in the nasal tract of healthy persons, and are often present in the nasal discharge in cases of angular conjunctivitis.

i It is not known how zinc acts in these cases, for the diplobacillus is in cultures very resistant to solutions of zinc. In more persistent cases Römer has used subcutaneous injections of a diplobacillus vaccine with good results.

j ? Zinc oxide (10%) or ichthyol (5-10%)

j especially near the outer canthi,

Pathology.—The disease is due to the Morax-Axenfeld diplobacillus (Fig. 99). The bacilli consist of pairs of large, thick rods, placed end to end. They stain well with basic stains, are decolourised by Gram, and are easily recognised in films. There is an incubation period of four days.

Treatment. — Diplobacillary conjunctivitis responds readily to zinc salts. These may be applied in the form of boric lotion with zinc sulphate, gr. ii. to ℥ i., or as drops, preferably the former. Boric ointment is applied to the lids at night.

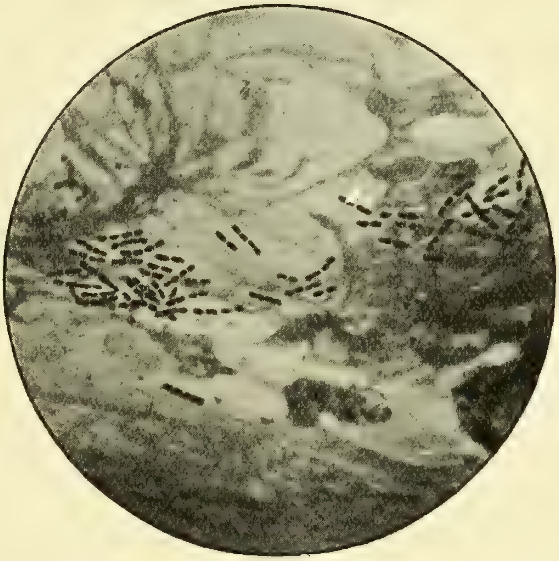


Fig. 99.—Diplobacilli (× 1000).

Follicular Conjunctivitis occurs frequently in children and young adults, both eyes being affected. It is characterised by the formation of small round or oval translucent bodies, 1 mm. or 2 mm. in diameter, in the lower fornix (Plate IV., Fig. 2); they are less commonly seen in the upper fornix, never on the plica semilunaris or bulbar conjunctiva. They are raised above the surface, are often arranged in parallel rows, and consist of localised aggregations of lymphocytes—follicles, sometimes wrongly termed granulations—in the sub-epithelial adenoid layer.

Microscopically follicles are indistinguishable from the solitary lymph patches in the intestine, and often also from the follicles of trachoma (*q.v.*). They do not occur in the normal conjunctiva in man. The conjunctiva is not reddened or swollen. They persist for an indefinite time, causing few symptoms, and disappear without leaving any trace, such as scarring (cf. Trachoma).

Follicular conjunctivitis is usually due to overcrowding, living in badly ventilated rooms, especially schoolrooms, and so on. Isolated follicles may occur in the outer part of the lower fornix in any chronic conjunctivitis of long standing. They may be due to overuse of atropin or eserin (*vide* p. 210). The children are seldom robust, and adenoid vegetations in the throat, which are of a similar nature, are often present. The disease is probably not contagious, and never develops into trachoma, as has been held by some good observers.

Treatment.—Follicular conjunctivitis seldom requires local treatment. A weak astringent lotion may be ordered, and yellow oxide of mercury introduced within the lids once or twice a day. If the follicles are very large painting with silver nitrate solution will do good. Atropin, if in use, should be stopped or replaced by an equivalent (*vide* p. 210).

Special attention should be directed to the refraction, and any errors corrected.

The general health and surroundings must be investigated and put upon a sound basis.

Trachoma (*Syn.—Granular Conjunctivitis*) is a much more serious form of folliculosis, which is responsible for the blinding of enormous numbers of people in places where it is endemic. Both eyes are almost always affected. It may be stated at once that in England it is a rare disease except where large numbers of Irish or aliens are herded together.

In making a diagnosis the relative frequency of various forms of disease should always be borne in mind. It is a truism, but it is often disregarded, that an unusual type of case is less likely to be a rare disease than an unfamiliar manifestation of a common one. A better class child with

b) Single follicles may be touched with the alum pencil.

c) mydriatic!

follicles in the conjunctiva is most unlikely to be a case of trachoma, whereas, if the child goes to a board school in the east end of London, where there are large numbers of trachomatous aliens, the distinction of follicular conjunctivitis from trachoma becomes a matter of great difficulty.

The changes met with in the conjunctiva in trachoma are of two types, which are often present simultaneously. The *papillary* type is not specially characteristic; it is usually a more definite form of the papillary enlargement and congestion which is met with in other severe forms of conjunctivitis. The conjunctiva covering the upper tarsus is most affected, and appears red and velvety. This condition may pass into one with more uniform jelly-like thickening. Only in the comparatively infrequent cases in which no follicles can be seen will the true disease pass wholly unsuspected.

The *follicular* type (Fig. 100) manifests itself in the presence of follicles in the conjunctiva. When small they cannot be distinguished from the follicles of follicular conjunctivitis, and microscopical examination shows that they are fundamentally identical. They often, however, assume a size and appearance which is seldom or never seen in follicular conjunctivitis, but they differ most in having a characteristic distribution. The large follicles may be 5 mm. or 6 mm. in diameter They are translucent and look like grains of boiled sago ("sago grains").

The follicles usually commence in the lower fornix, but in most cases they quickly appear in the upper also. Unlike what obtains in follicular conjunctivitis they are not limited to the fornices. They often form a row along the upper margin of the upper tarsus, whence they invade the palpebral conjunctiva, appearing upon the tarsal surface, though they are less numerous in this situation.

They are common about the caruncle, and may be seen on the plica semilunaris. They are very rare on the bulbar conjunctiva, but when seen here they are pathognomonic of trachoma.

The disease is very chronic and leads to much irritation, photophobia, lacrymation, &c., with some muco-purulent discharge. In certain districts abroad trachoma is endemic, and a very acute form is observed. It is very doubtful if true acute trachoma is ever seen in England: what usually passes for it is of quite different origin. It is due to the lowering of resistance of the trachomatous conjunctiva, whereby it becomes specially liable to intercurrent attacks of other forms of acute conjunctivitis. This is facilitated by the irritation, which leads to rubbing of the eyes, so that contamination is readily brought about. The so-called acute trachoma met with in England is therefore chronic trachoma upon which an acute muco-purulent or purulent conjunctivitis has been engrafted.

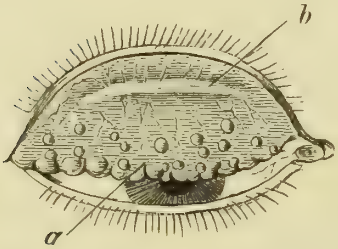


FIG. 100. — Trachoma. (Nettleship.) *a*, trachoma follicles; *b*, scar in typical position, parallel with the edge of the lid.

Trachoma is an extremely contagious disease. Pathological anatomy reveals nothing characteristic, for it is doubtful if the recently discovered "trachoma bodies" are truly pathognomonic: there is lymphocytic infiltration of the whole of the adenoid layer of the parts of the conjunctiva affected. Special aggregations of lymphocytes, without a definite capsule, form follicles which are generally indistinguishable from those of follicular conjunctivitis. In late stages and large follicles the stroma and cells tend to become hyaline and gelatinous; sometimes the surface becomes broken and the contents are extruded into the conjunctival sac. In other cases a

Follicles do not occur on the upper lid conjunctiva in follicular conjunctivitis except at the inner & outer angles.
~~In these cases [illegible] in trachoma.~~

a,p

¶ | Trachoma in the early stages may be easily mistaken for a simple catarrhal conjunctivitis. This error can be avoided if it be made an invariable rule in all cases of conjunctivitis to evert the upper lids & examine the upper fornices (v. p. 94).

fibrous capsule forms around the follicles, which thus become isolated: more and more fibrous tissue is laid down, giving rise to cicatricial bands such as are never formed in follicular conjunctivitis, and are very characteristic.

Bacteriology has failed to elucidate the pathology of the disease. Various specific organisms have been described, but all have failed to resist criticism.

Trachoma is endemic in many parts of the world, *e.g.*, Russia, Poland, East Prussia, parts of Austria-Hungary, Egypt, &c. It shows a predilection for certain races, *e.g.*, Irish, Jews, but it is not a racial disease; the predilection depends upon the mode of life of the individuals. Extended observation militates against the view that any race is exempt.

The disease flourishes amongst people who are crowded together in unhealthy rooms—in armies, navies, asylums, workhouse schools, &c.—wherever the lower classes are herded together. Children and debilitated adults are most susceptible, but the robust are not exempt. It is commoner in low-lying, damp districts.

The disease is spread by transference of conjunctival secretion by means of fingers, towels, &c. The presence of much discharge, whether of true trachomatous origin or due to intercurrent conjunctivitis, increases the liability of contagion. On the other hand, scrupulous cleanliness suffices to prevent the extension of the disease to healthy subjects.

Complications.—Whilst trachoma very rarely affects the bulbar conjunctiva it not infrequently attacks the cornea.

Trachomatous pannus is a lymphoid infiltration, with vascularisation, of the margin of the cornea, usually limited to the upper half (Figs. 101, 67 C), but tending to spread towards the centre and to involve the whole cornea. The upper part of the margin of the cornea becomes cloudy, and minute superficial vessels, springing from the corneal loops, grow inwards towards the centre. The haziness and vascularisation increase until the upper half of the cornea is affected. The vessels are all superficial (*vide* p. 106), and microscopic examination has shown that they lie at first between Bowman's membrane and the epithelium. They carry in with them a small amount of granulation tissue. In later stages Bowman's membrane disappears and the superficial layers of the substantia propria become involved.

In progressive pannus the vessels are mostly parallel to each other and directed vertically downwards, anastomosing little. They extend to a level which forms a horizontal line, and beyond this line there is a narrow strip of infiltration and haze. In regressive pannus, on the other hand, the vessels extend a short distance beyond the area which is infiltrated and hazy: this difference is useful in estimating the results of treatment.

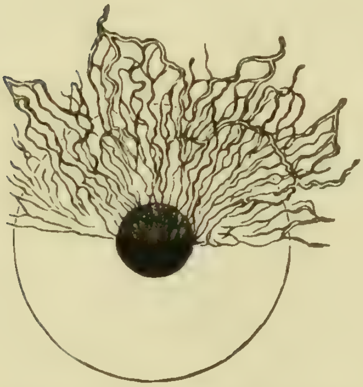


FIG. 101. — Trachomatous pannus. (Nettleship.)

In more severe cases the vascularisation is not limited to the upper part, but superficial vessels grow in from all sides and the whole cornea becomes vascularised and opaque.

Pannus is not due to the rough upper lid rubbing upon the cornea. This is doubtless a predisposing factor, but in many conditions in which the lids are rough from some other cause pannus does not occur. It is not due to continuity, since the bulbar conjunctiva from the limbus to the fornix is unaffected. It is induced by contiguity, probably by direct infection, and this part of the cornea is most affected because it is covered by the lid both day and night.

(31) Pressure on the section after [illegible] with [illegible] the appearance of
a white [illegible] which are to be mistaken for [illegible]
Staining. They [illegible] be distinguished by [illegible] the presence.

(32) In the late stages the follicles invade the tumour, causing softening &
absorption of the dense fibrous tissue;
[new-formed | the hairs |

It may resolve completely, leaving the cornea quite clear, but only in cases treated early, when the vessels have not yet destroyed Bowman's membrane. In other cases a permanent opacity results. Occasionally the corneal substance becomes weakened so that the cornea bulges under normal intraocular pressure and ectasia follows (keratectasia).

Corneal Ulcers are commonest at the advancing edge of the pannus. They are shallow, little infiltrated, and very irritable, causing much lacrymation and photophobia. Indolent central ulcers may form, or there may be ulcers in any part of the cornea, but especially over the pannous area.

Sequelæ.—Apart from the results of pannus and corneal ulceration the most malign effects of trachoma are caused by distortions of the lids. A peculiar drooping of the upper lids is very characteristic (*trachomatous ptosis*). It gives a sleepy appearance to the patient. There is always some scarring (Fig. 100), and when this is extensive the shape and position of the lids, especially the upper, are altered. Through the great swelling of the conjunctiva they may be turned outwards (ectropion), ~~and~~ through the later contraction of the scar tissue ~~they~~ may be turned inwards (entropion), causing the lashes to rub against the cornea (trichiasis), &c. (*See* Chap. XXIX.)

Treatment.—If there is much discharge the case must first be treated with a view to diminishing it and reducing congestion. The lids should be painted once daily with silver nitrate solution ; sublimate lotion should be thoroughly used three or more times a day, and boric ointment applied to the edges of the lids at bed-time.

In a few days the conjunctivitis will be much less, and an attempt must be made to get rid of the follicles. In relatively slight cases this is best affected by scouring the conjunctiva with a smooth crystal of copper sulphate. The crystal is fixed in a wooden holder and is pointed at the end.

The lids are everted, and the point of the copper stick is pushed well up into the upper fornix and moved from one side to the other, the lid being lifted away from the globe by the stick during the manœuvre so as to avoid touching the cornea. The stick is then rubbed firmly over the whole of the palpebral conjunctiva.

The application of the copper stick is very painful, especially during the first few applications. Cocain may be previously instilled, but it does not prevent the intense smarting. It is important to start with the upper fornix, since this is most affected and most difficult to reach; if it is not done first blepharospasm and the struggles of the patient will make it impossible afterwards. It is useless to apply copper too gently; it must be firmly rubbed into the conjunctiva. Some of the sulphate dissolves in the tears, and should be mopped up with a pad of dry wool, since it is very irritating to the cornea. Pannus is no contraindication to the use of the copper stick, but quite the reverse; copper sulphate applied to the lids is the best treatment for pannus. The pannus itself is not treated directly at all. On the other hand, corneal ulceration of any kind or degree is an absolute contraindication; in these cases, even if pannus is present, reliance must be placed on silver nitrate until the ulcers are healed. Unfortunately silver has little specific influence over the trachomatous process, whereas that of copper is undoubted.

The copper stick must be applied once daily, otherwise the case is certain to run on indefinitely. Sublimate lotion is ordered for home use as before.

In most cases of trachoma the treatment advised will suffice to bring about that condition of amelioration which is usually described as cure. Relapses are common, occurring sooner or later, according to the length and assiduity of treatment. I am doubtful myself whether trachoma is ever really cured by the methods adopted.

(33)

Active treatment should be carried out for many weeks & should be continued for several weeks after apparent cure. In the later stages copper sulphate (grs. i 8. | ad ℥i), or copper sulphate) or citrate) ointment may be used.

½–1%   10%

34

One method seldom employed [illegible] [illegible] is inoculation or injection of jequirity (Abrus precatorius), which sets up a violent reaction. Jequiritol, the active principle, can be standardized & its action controlled by an antitoxin. — This treatment is more risky & probably not more efficacious than the methods about to be described.

35

CO_2 snow.

¶ The follicles may also be destroyed by touching them with a solid stick of carbon dioxide snow. — Care must be taken to allow time for thawing before the eye-lid is replaced. X-rays & radium have also been used, but do not give better results than the ordinary treatment.

36

sharp spoon or stiff tooth-brush. — The follicles may also be destroyed by the galvano-cautery or by electrolysis.

In severer cases more drastic remedies must be employed. Probably the best of the stronger applications is a concentrated solution of perchloride of mercury in glycerine. It has been used as strong as 4 per cent.; under these circumstances it acts as a caustic. It is painted on the fornix and everted lids. This treatment is almost unbearably painful, and is followed by intense reaction, the conjunctiva and lids becoming enormously swollen. The pain lasts for several hours, gradually diminishing in intensity. Ice, or lint wrung out in iced water, should be applied to the lids immediately after the application. There is no doubt that much benefit is derived from the treatment.

When the follicles are numerous and very prominent the treatment is shortened by attacking them mechanically. It may be done by various forms of scarification or expression. In performing any operation upon trachomatous patients protective goggles must be worn by the surgeon and the immediate attendants.

The conjunctiva is first thoroughly cocained. Scarification may be performed with the finger nails — an objectionable practice—or by a knife ~~or sharp~~ needle.

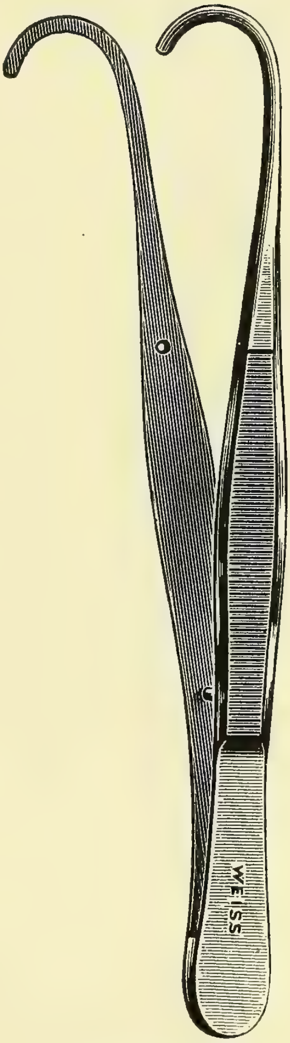


Fig. 102.—Graddy's forceps.

In *expression* one of the many forms of expressor is used—*e.g.*, Graddy's forceps (Fig. 102), Knapp's roller forceps (Fig. 103). The upper lid is everted, and one limb of the forceps is pushed up into the fornix, the other being laid upon the palpebral conjunctiva. The two limbs are then pressed together with moderate force and are drawn in a horizontal direction from one end of the fold to the other. The fold of the fornix should in this manner be thoroughly mangled, and all the follicles squeezed out. Some recommend the immediate application of sublimate solution (1 in 2000), but it is best simply to apply cold compresses, since there is always considerable reaction.

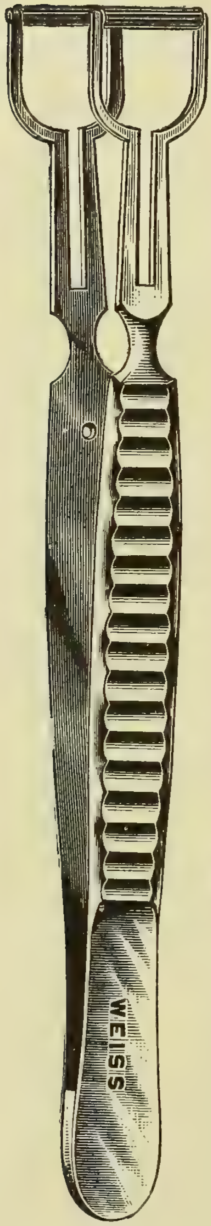


Fig. 103.—Knapp's roller forceps.

If the follicles in the upper fornix are very large and closely packed it is well to commence treatment by excising the fornix. There is always a redundance of tissue here, and no evil results ensue. The upper lid is everted doubly (*vide* p. 94) so as to expose the retrotarsal fold completely. A silk suture is then passed through the fold at each end. By dragging on the sutures the whole fold is drawn out. It is then excised with scissors.

Pannus requires no special treatment, but corneal ulcers must be treated on general principles (*vide* p. 231).

Hygienic treatment must be carried out so far as practicable. The influx of aliens into the east end of London has made trachoma a serious menace to our own population. The exclusion of trachomatous aliens is urgently demanded. The isolation of trachomatous school children is being carried out by the Metropolitan Asylums Board.

Tubercle of the Conjunctiva is rare: it nearly always produces ulceration. Conjunctival ulceration should always suggest either the presence of an imbedded foreign body or a tuberculous or syphilitic lesion.

L silver nitrate or /

1 If the tarsal plate is very much diseased or distorted it also may be excised.

(37) L if it fails to respond a peritomy may be performed. 2 In this operation a collar of conjunctiva, 5 mm. broad, is excised round the corneal margin. The raw surface may be seared with the ~~actual~~ c galvano-cautery, the object being to destroy the vessels & prevent their ~~reformation~~ re-formation.

(38)

¶ Trachoma, then known as Egyptian ophthalmia, was spread far & wide in Europe by the French armies during the Napoleonic wars. There is danger of a similar dissemination as a result of the present war. ~~There can be no doubt that trachomatous persons should be isolated in colonies on the same lines as trachoma schools, or discharged from the Army.~~

(38)

L If a piece of tuberculous tissue is introduced into the anterior chamber of a rabbit's eye a typical tuberculous iritis will ensue in two or three weeks. Intraperitoneal inoculation of guinea pigs is more satisfactory. Von Pirquet's reaction or injections of old tuberculin may be tried.

Tubercle occurs in several forms: (1) small miliary ulcers usually on the palpebral conjunctiva; (2) granules on the palpebral conjunctiva resembling trachoma follicles (Fig. 104); (3) gelatinous cockscomb-like excrescences on the fornices; (4) polypoid pedunculated outgrowths. The conjunctiva may be affected by extension of lupus from the face.

The preauricular gland is often enlarged and may suppurate. The disease is chronic, and the ulcers are indolent. The patients are usually young, and often free from clinical signs of tuberculous disease elsewhere in the body. There is very little doubt that the lesion may be the primary seat of tubercle, the bacilli being inoculated into minute abrasions, which are probably always present in the conjunctiva, caused by dust. There is little pain or irritation unless the ulceration is extensive.

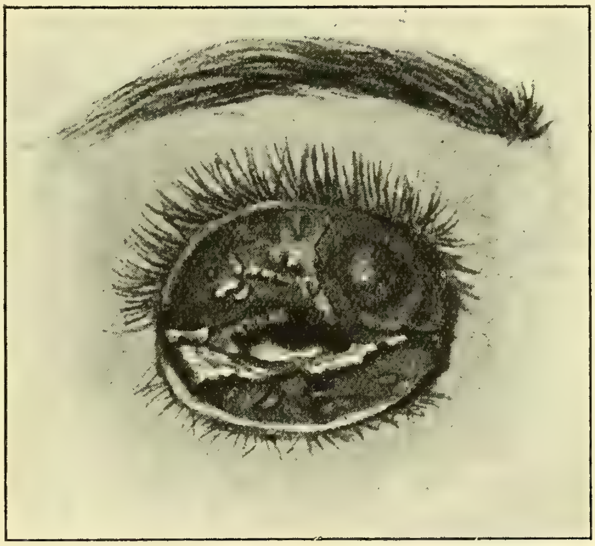


FIG. 104.—Tubercle of the conjunctiva (After Eyre.)

It is not improbable that the second type is frequently mistaken for trachoma, and it is possible that it is cured by the treatment founded on the wrong diagnosis.

Pathology. — Scrapings may show tubercle bacilli. Sections show typical giant-cell systems. In doubtful cases inoculation experiments should be made.

Treatment.—The disease should be eradicated, more especially as being often the primary focus. The affected conjunctiva should be excised, or if this is not feasible, thoroughly scraped and cauterised.

Injections of the latest form of tuberculin have given encouraging results, and subconjunctival injections of 2 per cent. guaiacol cacodylate may be employed.

Extension to the globe is probably rare. If prolonged treatment fails and the disease spreads it may be necessary to excise the eye.

Syphilis rarely manifests itself in the conjunctiva. Ulceration of the palpebral or still more of the bulbar conjunctiva is always suggestive of the condition. (*See* Chap. XXIX.)

Some Rarer Forms of Conjunctival Inflammation.—One or two rarer forms of inflammation of the conjunctiva demand passing notice since they may be mistaken for those already described.

Conjunctivitis caused by Drugs (Atropin Irritation, &c.).—Some people are particularly susceptible to atropin, and more rarely to eserin and other drugs, locally applied to the conjunctiva. The lids become swollen, tense, and red, in fact erysipelatous. Examination of the conjunctiva will often show follicles, and even rarely a membrane. The cause is obscure: sometimes the condition seems to be due to a special solution or brand of the drug, owing to some impurity. Workers with crysophanic acid suffer from conjunctival irritation, and prolonged internal administration of arsenic causes the same effect. The dust of teak wood is particularly irritating to the conjunctiva.

Treatment.—In atropin irritation the drug should be avoided. If a mydriatic is imperative, some other should be substituted, *e.g.*, duboisin sulphate, 0·5 per cent.; scopolamin hydrobromide, 0·25 per cent. to 0·5 per cent., or hyoscin, 0·5 per cent., may be used, but toxic symptoms sometimes occur. It is said that atropin may be continued

Scrapings should be taken & examined for the spirochaete, & the Wassermann test should be applied.

if it is scrupulously kept away from the skin by covering the lids with glycerine or ointment up to the margins.

The conjunctiva soon recovers after cessation of the cause, but astringent lotions accelerate the cure.

Spring Catarrh (*Syn.—Vernal Catarrh*).—This is a recurrent conjunctivitis occurring with the onset of hot weather, and therefore rather a summer than a spring complaint. It is found in young people, usually boys, associated with the usual symptoms of mild conjunctivitis. Burning, itching, some photophobia, and lacrymation are the chief symptoms. Both eyes are affected. In the cooler months the condition subsides and gives no trouble, but recurs with the return of heat. The disease is met with amongst all classes, is sporadic, and non-contagious. It has been attributed on insufficient grounds to the action of the actinic rays of the spectrum.

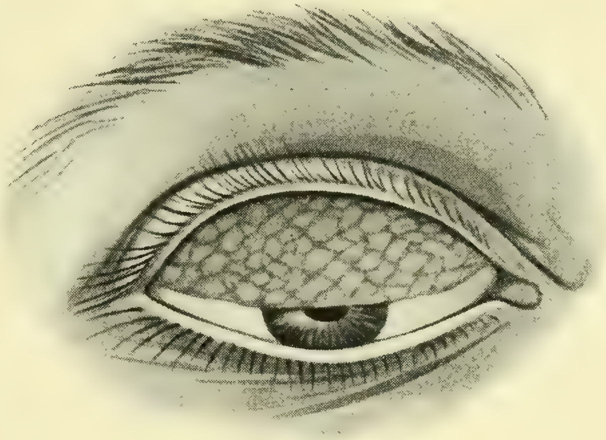


FIG. 105.—The palpebral form of spring catarrh.

Two types of objective signs are met with: (1) the palpebral form; (2) the bulbar form: both may be combined, but this is relatively rare. The palpebral form is easily recognised if typical. On everting the upper lid the palpebral conjunctiva is seen to be hypertrophied and mapped out into polygonal raised areas, not unlike cobble stones (Fig. 105). The colour is bluish white, like milk, and this appearance is seen also over the lower palpebral conjunctiva.

The flat-topped nodules are hard, and consist chiefly of dense fibrous tissue, but the epithelium over them is thickened, giving rise to the milky hue. In vertical section they resemble circumvallate papillæ. Eosinophile leucocytes are present in them in great numbers and may be found in the secretion.

The palpebral form cannot be mistaken if typical, but it may resemble trachoma. The type of patient, the milky hue, the freedom of the fornix from implication, and the characteristic recurrence in hot weather will usually prevent mistake.

The bulbar form is less characteristic. In it there is a wall of thickening at the limbus, more gelatinous in appearance, and also milky. It may be mistaken for phlyctenular conjunctivitis.

In both forms the lesions persist during the cold months, though they are less marked.

Serious complications never supervene, and the ultimate prognosis is good.

Treatment is purely symptomatic. Tinted glasses should be worn. The irritation is best relieved by very weak acetic acid, gt. i. to ʒ vi. Adrenalin gives temporary relief. Gentle massage with the upper lid after application of yellow oxide of mercury ointment or 1—2 per cent. guaiacol ointment is beneficial. Astringents are harmful: boroglyceride has been recommended, with arsenic internally. Excision of the nodules, sometimes advised, seems to be useless.

Ophthalmia nodosa is a nodular conjunctivitis which may be mistaken for tubercle—pseudo-tuberculous disease of the conjunctiva. It is due to the irritation of the hairs of certain caterpillars, and therefore always commences in the late summer months. Small semitranslucent, reddish, or yellowish grey nodules are formed in the conjunctiva and sometimes in the iris. On microscopical examination

(40)

[Occasionally a peculiar corneal opacity, resembling arcus senilis in having a clear zone between it & the limbus, is left, & some thickening of the semilunar fold of the conjunctiva may remain.

[Well-fitting goggles with |

[Radium applications have given relief in some cases.

[The general health should be attended to, & adenoids & enlarged tonsils, if present, removed.

¶ Parinaud's Conjunctivitis may be mistaken for tubercle or trachoma. Usually one eye only is affected. ~~there~~ Granulations occur on the tarsal conjunctiva or fornices & the preauricular & submaxillary glands are enlarged & may suppurate. The disease commences with slight constitutional disturbance & may last for months. It has been attributed to bovine tubercle & to a leptothrix (Verhoeff)

x'

The condition is generally caused by the bright flash of a short-circuit, but may result from exposure to a naked arc light. It is rarely due to exposure to enclosed arcs & or other lights since the glass globe absorbs the most deleterious of the ultra-violet rays.

especially from 310μμ – 290μμ,

viz, exposure to ~~to~~ ultra violet rays, an unusually large percentage of which ~~and~~ is reflected from snow surfaces.

~~[illegible]~~

& these are ~~[illegible]~~ most efficacious when made with Crookes's glass (v. p. 174).

hairs surrounded by giant cells and lymphocytes are found.

Treatment.—The nodules in the conjunctiva should be excised. Otherwise the condition is treated on general principles.

Electric Light Ophthalmia (Photophthalmia).—The ultraviolet rays of the electric light~~, especially of the arc lamp,~~ may cause extreme burning pain, lacrymation, photophobia, blepharospasm, and swelling of the palpebral conjunctiva and retrotarsal folds, coming on a few hours later.

Treatment.—Cold compresses~~, dark glasses~~, and astringent lotions.

Snow Blindness.—The cause and symptoms of snow blindness are the same as of electric light ophthalmia. Smoked or orange tinted (not blue) glasses should be used as a prophylactic measure. The treatment is the same as for electric light ophthalmia.

DEGENERATIVE CHANGES IN THE CONJUNCTIVA.

Concretions (*Syn.*—"*Lithiasis*").—Concretions occur as minute hard yellow spots in the palpebral conjunctiva. They are due to the accumulation of epithelial cells and inspissated mucus in depressions which are called Henle's glands. They never become calcareous, so the term is a misnomer, but they are so hard that when they project from the surface they scratch the cornea and give the sensation of a foreign body in the eye. They are common in elderly people. There is no reason to attribute them to gout, but uric acid deposits have been observed in the palpebral conjunctiva of gouty patients. Concretions should be removed with a sharp needle.

Pinguecula is a triangular patch on the conjunctiva, found usually in elderly people, especially those exposed to dust, wind, and so on. It occurs in the direction of the palpebral aperture, the apex of the triangle being away from the cornea. It affects the nasal side first, then the temporal. It is yellow in colour and looks like fat, whence the name (pinguis, fat). It is not due to fat, but to an excessive development of yellow elastic fibrous tissue. It is particularly conspicuous when the eye is inflamed, since the pinguecula remains relatively free from congestion: mistakes in diagnosis may then occur. It requires no treatment, but may be removed if the disfigurement is great.

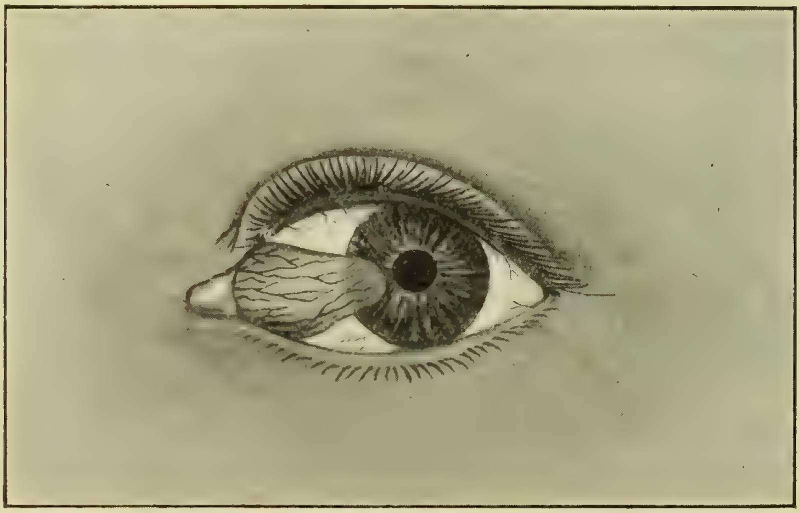


FIG. 106.—Pterygium.

Pterygium (πτέρυξ, a wing).—This is a peculiar encroachment of the conjunctiva on the cornea (Fig. 106). It is triangular in shape, and when single is always upon the nasal side; when double the temporal one has developed later. It is derived from pinguecula. It must be carefully distinguished from *pseudo-pterygium*, which is due to the tip of a fold of chemotic conjunctiva becoming adherent to an ulcer within the corneal margin. It may occur at any part of the cornea. The conjunctiva then forms a bridge over the limbus, and a fine probe can always

Cf. Pterygium is rare in England, but is common in dry climates with
& sandy soils, e.g. parts of Australia, South Africa, Texas, &c.

be passed beneath it, which is not possible with a true pterygium.

The apex of the pterygium is usually blunt; there is no ulcer in the cornea beyond it, as formerly described, but there are often small opacities. In the early stage the pterygium is thick and vascular; it advances over the cornea and may reach the pupillary area and interfere with vision. When it ceases to grow it becomes thin and pale, but never disappears.

The true pterygium is a single layer of conjunctiva, adherent in its whole length to the sclerotic and cornea, though only loosely, except at the apex. The area of adhesion is always smaller than its breadth, so that there are folds at the upper and lower borders.

Pterygium is not due to a fold of conjunctiva being dragged across the cornea by a progressive ulcer as was once taught. It is probably due to malnutrition of the cornea, resulting from the pinguecula. Granulation tissue grows in and invaginates the epithelium, destroying Bowman's membrane. When it ceases to progress dense fibrous tissue is formed.

Treatment.—Pterygium is best left alone unless it is progressing rapidly towards the pupillary area, or is very disfiguring. The latter reason is not of much weight, since it cannot be removed without leaving a scar.

The apex of the pterygium may be destroyed with the actual cautery. Removal is effected by seizing the neck, near the corneal margin, with fixation forceps, raising it, and shaving or dissecting the apex from the cornea. Care must be taken not to go too deep. The pterygium is freed from the sclerotic for about half the distance towards the canthus. Two converging incisions with scissors separate the apex and greater part of the body. The conjunctiva is then freed from the sclerotic above and below so as to admit of the two edges being sutured together.

Pterygium sometimes recurs after removal. This may be only apparent, owing to vascularisation of the denuded area. If it actually re-forms and extends towards the pupillary area, it must again be removed.

Symptomatic Conditions.

Subconjunctival Ecchymosis, due to the rupture of small vessels, frequently occurs. It may be the result of direct injury, or, more commonly, occur spontaneously. Very minute ecchymoses, or possibly thromboses, are seen in severe conjunctivitis, especially pneumococcic. Larger ones accompany severe straining, especially in old people, *e.g.*, on lifting heavy weights, vomiting, &c. In these circumstances they indicate a weakness of the vessel walls, and should be regarded as a danger signal. Other signs of arterio-sclerosis should be sought in the fundus oculi and elsewhere, and, if found, warning of the possibility of cerebral hæmorrhage given, with appropriate instructions for its avoidance. Very frequently no such signs can be discovered, and the condition, though unsightly, is trivial. Subconjunctival ecchymoses are not infrequently seen in children with whooping cough; they need arouse no anxiety.

More serious are the large subconjunctival ecchymoses which sometimes follow blows or falls on the head. They may then be due to extravasation of blood along the floor of the orbit, the result of a fractured base.

The importance of subconjunctival hæmorrhage is always symptomatic, since the eye itself is never endangered.

Treatment.—The blood becomes absorbed in from one to three weeks without treatment. Boric lotion is usually ordered as a placebo. Dionin may be used to accelerate absorption in young patients, but should not be employed in elderly subjects with arteriosclerosis.

h as a rule / h, but retinal haemorrhages, hyphaema also occur, as well as cerebral haemorrhages producing paralyses of cranial nerves or homonymous hemianopia.

(44) h In fractures of the sphenoid the blood appears later on the temporal side than elsewhere. Severe haemorrhages also result from severe or prolonged pressure on the thorax & abdomen, as in persons squeezed in a crowd.

Subconjunctival haemorrhages may occur in scurvy, purpura, malaria, & so on.

45) Chemosis, or oedema of the conjunctiva, may occur in (1) acute inflammations; (2) in cases of obstruction to the lymph flow, & (3) in abnormal blood conditions.

In the first group of cases the inflammation may be in the conjunctiva, e.g. gonorrhoeal conjunctivitis, or within the eyeball, as in panophthalmitis, hypopyon ulcer. It is also found in acute glaucoma. The inflammation may be in the accessory structures of the eye, e.g. a stye, a parasitic bite in the lids, dacryocystitis, periostitis, orbital cellulitis, cerebro-spinal meningitis.

In the second group the presence of an orbital tumour may so interfere with the lymph stream as to produce chemosis, & it is found in pulsating exophthalmos. ~~The chemosis of [illegible] is [illegible]~~

The chemosis of this is probably due to a specific irritation of the conjunctival vessel walls.

To the third group belong Bright's disease & the anaemias. It is sometimes due to urticaria or angioneurotic oedema. Recurrent chemosis is sometimes associated with menstruation, & it has been observed in trigeminal neuralgia & migraine.

Xerosis

Xerosis (*Syn.—Xerophthalmia*) (ξηρός, dry) is a dry, lustreless condition of the conjunctiva which occurs in two groups of cases: (1) as a sequel of local ocular affection; (2) associated with general disease.

The first type is a cicatricial degeneration of the conjunctiva—(a) following trachoma, burns, pemphigus, diphtheria, &c., commencing in isolated spots, ultimately involving the whole conjunctiva and cornea; (b) following exposure, due to ectropion or proptosis, whereby the eye is not properly covered by the lids. As the result of the rare affection of the conjunctiva with pemphigus the cicatricial contraction of the conjunctiva may be extreme and progressive, a sort of keloid condition being induced (*essential shrinking of the conjunctiva*): the lids may then be quite adherent to the globe, the cornea being opaque like skin.

In the other group of cases xerosis occurs in a mild form, found in children, usually boys, accompanied by night blindness (Chap. XX.), and characterised by small triangular white patches on the outer and inner sides of the cornea, covered by a material resembling dried foam, which is not wetted by the tears. The cases usually occur during the summer months, and the children are not conspicuously ill-nourished. A similar mild form, also associated with night blindness, is met with in adults in some countries, *e.g.*, India, but seldom if ever in England. A severe form is found in marasmic children, associated with keratomalacia (*vide* p. 253) and necrosis of the cornea.

Pathology.—The chief changes are in the epithelium, which becomes epidermoid, *i.e.*, exactly like that of skin, with granular and horny layers. The foamy spots are due to horny epithelium, which becomes cast off into the conjunctival sac and accumulates in the lower fornix. Owing to this change the epithelium ceases to secrete mucus. It becomes dry; a certain amount of vicarious activity is set up in the Meibomian glands (Chap. XXIX.), which cover the surface with their fatty secretion. The watery tears then fail to moisten the conjunctiva. The so-called xerosis bacilli, which are pseudo-diphtheria bacilli, grow profusely under these conditions, but they have no causal relationship and are of no importance.

It is to be noted that xerosis has nothing to do with any failure of function on the part of the lacrymal apparatus. The conjunctiva can be quite efficiently moistened by its own secretions alone. If the lacrymal gland is extirpated xerosis does not follow. If on the other hand the secretory activity of the membrane itself is impaired xerosis follows, in spite of normal or increased lacrymal secretion.

Treatment.—Xerosis is a symptom, and its treatment must therefore be purely symptomatic. Local treatment consists in relieving the dryness with boric acid ointment, olive oil, milk, weak alkaline solutions, &c. : smoked glasses should be worn.

In the marasmic cases restoration of normal nutrition is the all-important aim, though the patients have often gone too far.

CYSTS AND TUMOURS.

The only common **cysts** found in the conjunctiva are due to dilatation of lymph spaces. When small these often form rows of little cysts on the bulbar conjunctiva (*lymphangiectasis*). Occasionally single, though multilocular, cysts occur (*lymphangioma*). Larger retention cysts of Krause's accessory lacrymal glands occur in the upper fornix (Chap. XXIX.). Subconjunctival cysticercus and hydatid are rare in England. Non-parasitic cysts require simple removal of the anterior walls.

Tumours of the conjunctiva have all a tendency to be

(46) f. **Argyrosis** is the staining of the conjunctiva from prolonged use of applications of silver salts (mostly prolonged ?) (for the treatment of chronic conjunctivitis, especially trachoma. The conjunctiva, particularly the lower fornix is stained deep brown. The staining is due to the ~~deposition of~~ impregnation of the elastic fibres in the membrane & vessel walls with reduced metallic silver. The condition is very difficult to get rid of, but subconjunctival injections of potassium iodide (m ii–iv of a 30% solution) have been advocated.

They also occur rarely at the [illegible] in old people & are then
liable to become malignant –

polypoid, owing to the perpetual movements of the globe and lids.

Papillomata occur at the inner canthus and in the fornices. In the latter position they may be mistaken for the cockscomb type of tubercle, but the individual leaflets may be separated by a probe. They should be ~~snipped off~~. [illegible]

Simple Granulomata, generally polypoid, often grow from tenotomy wounds or the sites of foreign bodies. They consist of ordinary exuberant granulation tissue. They are common in empty sockets after excision, and at the site of chalazions which have been insufficiently scraped (Chap. XXIX.). They should be removed by scissors.

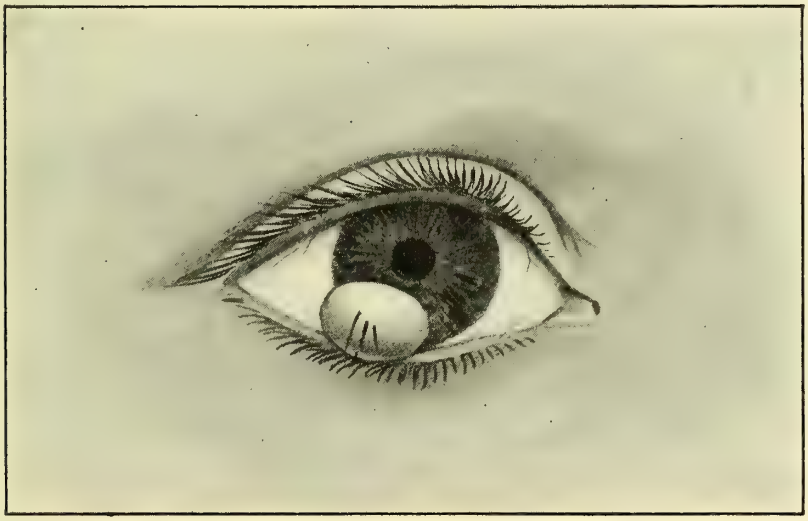


FIG. 107.—Dermoid of the conjunctiva, in a somewhat unusual situation. Note the hairs.

Fibromata, also generally polypoid, occur in sockets. They may be soft or hard, and require simple removal.

Nævi or *congenital moles* are not uncommon. They are white gelatinous or pigmented nodules situated by preference at the limbus or near the plica semilunaris. They have the same structure as in the skin—groups, often alveolar, of "nævus cells" in close connection with the epithelium. They are congenital and tend to grow at puberty, rarely becoming malignant. They should be excised.

Dermoids are lenticular yellow tumours, usually astride the corneal margin, most commonly at the outer side (Fig. 107). Not infrequently there is a notch in the upper lid corresponding with the position of the tumour. They consist of skin in an abnormal situation, with epidermoid epithelium, hairs, sebaceous glands, &c. They are congenital and tend to grow at puberty. ~~They~~ should be ~~removed~~.

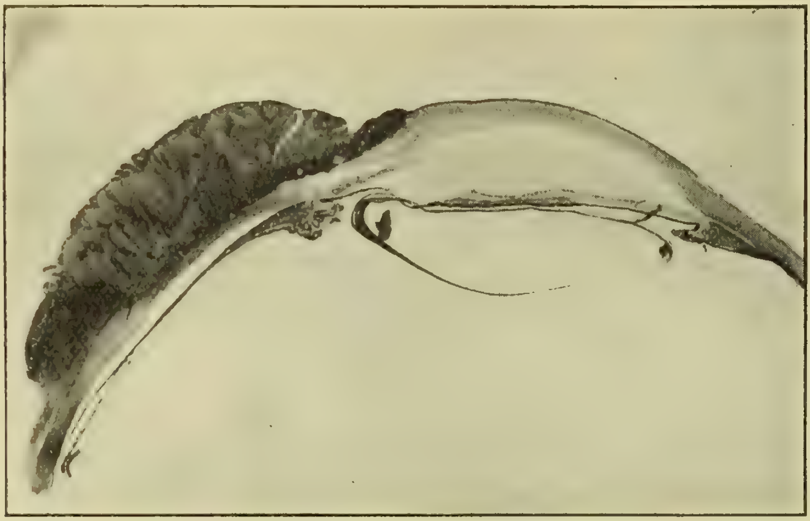


FIG. 108.—Epithelioma of the conjunctiva, from a section (× 6).

Dermo-lipomata or *fibro-fatty tumours* are congenital tumours found at the outer canthus in babies. They consist of fibrous tissue and fat, sometimes with dermoid tissue on the surface. They are not encapsuled. The main mass should be removed, but it will be found that the fat is continuous with that of the orbit: care must be taken not to injure the extrinsic muscles.

Sarcoma is rare. It occurs at the limbus, is usually pigmented, and most of the patients have been old. Sarcomata spread over the surface of the globe, but rarely penetrate it. Recurrence and metastasis occur as

They are often wrongly called dermoids of the cornea.

the hairs They becoming much longer & often irritating the cornea.

if troublesome, though their removal does not produce much improvement in appearance, as the site of attachment to the cornea remains densely opaque.

~~C~~ a diffuse, spreading pigmentation of the conjunctiva occurring late in elderly people, has been known to give rise to metastatic Sarcomatous tumours. It should always be viewed with grave suspicion ~~& appropriate treatment adopted~~.

elsewhere in the body. They may be alveolar—derived from nævi—or round or spindle celled. They must be removed as freely as possible and examined microscopically. On the slightest sign of recurrence the eye must be excised, and if recurrence again takes place the orbit must be exenterated.

Epithelioma occurs par excellence where one kind of epithelium passes into another, hence in the eye chiefly at the limbus (Fig. 108), and at the edges of the lids. Papillomata in old people often take on malignant proliferation. Like sarcomata, epitheliomata spread over the surface and into the fornices, rarely penetrating the globe. They have the characteristic structure. The treatment is the same as for sarcoma: it is well in both cases to cauterise the base with the actual cautery after the first removal.

CHAPTER XI.

DISEASES OF THE CORNEA.

The special importance of diseases of the cornea depends upon the fact that they often leave permanent opacities which seriously lower the visual acuity, whilst the complications which not infrequently attend them may lead to the loss of the eye.

Inflammation of the Cornea (Keratitis).

Inflammation of the cornea may be purulent or non-purulent. An immense amount of research has been devoted to inflammation of the cornea from the earliest investigations of Bowman (1849) onwards, and much of our knowledge of inflammation in general is derived from these researches.

Purulent Keratitis, Ulceration of the Cornea.—Purulent keratitis is nearly always exogenous, *i.e.*, it is due to pyogenic organisms which invade the cornea from without. The first line of defence is the epithelium. It has been pointed out that the only organisms which are known to be able to attack normal epithelium are the gonococcus and the diphtheria bacillus; but many other bacteria are capable of producing ulceration, notably the pneumococcus.

When we remember the exposed position of the cornea it is not surprising that minute abrasions are extremely common. They are probably of everyday occurrence, but other factors have also to be reckoned with. Pathogenic organisms of high virulence are not always present

Diseases of the cornea form about 20 per cent of all eye diseases.

in the conjunctival sac, and if they are, as is often the case, the resistance of the normal tissues has to be taken into account. It is too often forgotten that normal tissues with a healthy blood supply and lymph flow are well armed against any but the most virulent invaders. Even with these prolonged contact is usually necessary.

Apart from actual abrasions many causes of diminished resistance of the epithelium are met with. Such are drying, as in xerosis, necrosis due to deficient nutrition, as in keratomalacia, desquamation as the result of œdema or neuro-paralytic keratitis. If cocain is instilled too freely, especially if the lids are not kept closed in the intervals, the epithelium becomes dull and is finally thrown off. Hence this drug is to be used with caution and only under supervision; it should seldom if ever be given in lotions for use at home.

Malnutrition affects not only the epithelium but also the whole cornea. In badly nourished corneæ ulceration is apt to be deep, leading to early perforation, and also extensive, resulting in widespread necrosis. Such septic ulcers, due to the attack of ordinary pyogenic organisms, occur after injuries in asthenic conditions in keratomalacia, lagophthalmia, &c. Corneal ulcers are much commoner in the lower orders, doubtless owing to the defective resistance of the tissues and the more frequent exposure to injury.

In the commonest form of suppurative keratitis—the corneal ulcer—there is localised necrosis in the most anterior layers of the cornea. The sequestrum is partly disintegrated and cast off into the conjunctival sac, and partly adhers to the surface of the ulcer. Usually the epithelium is destroyed and cast off over an area considerably larger than the ulcer itself, and the same applies to Bowman's membrane. The epithelium, however, rapidly advances towards the ulcer, grows over its edge, and even over the slough or pus which forms the floor.

The ulcer is usually saucer-shaped, and the walls project above the normal surface of the cornea (Fig. 109), owing to the imbibition of fluid by the corneal lamellæ, which causes them to swell. The spaces between the lamellæ are packed with leucocytes for some distance around the ulcer, appearing as a grey zone of infiltration. This is the progressive stage.

A line of demarcation forms as in necrosis elsewhere in the body. The toxins are most concentrated near the centre where there are most organisms. A wall of polymorphonuclear leucocytes forms a second line of defence. At a certain distance the tissues are protected; here the leucocytes are not paralysed or killed by toxins, but exert their digestive functions, macerating and dissolving the necrotic tissues. When the dead material has been thrown off the ulcer is somewhat larger, but the cloudiness has disappeared, the floor and edges are smooth and transparent, and the regressive stage is reached.

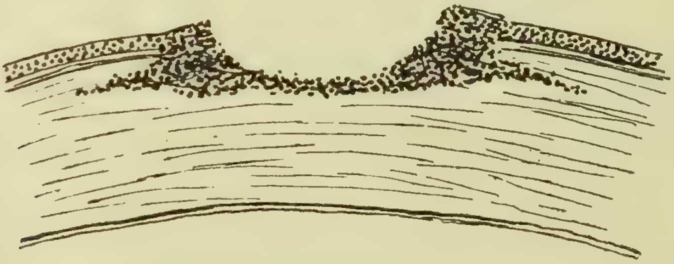


FIG. 109.—Vertical section of a corneal ulcer, showing infiltration of the substantia propria.

Meanwhile vascularisation has been going on (Plate V., Fig. 1). Minute superficial vessels grow in from the limbus near the ulcer. They supply the pabulum to restore the loss of substance. Sometimes they are so exuberant as to overstep the limits of utility, *e.g.*, in fascicular ulcer (*vide* p. 250).

When the ulcer has become vascularised, everything is prepared for cicatrisation, which is carried out exactly

L: They also supply protective substances — antibodies — [illegible] play an important role in combatting bacterial infection.

PLATE V.

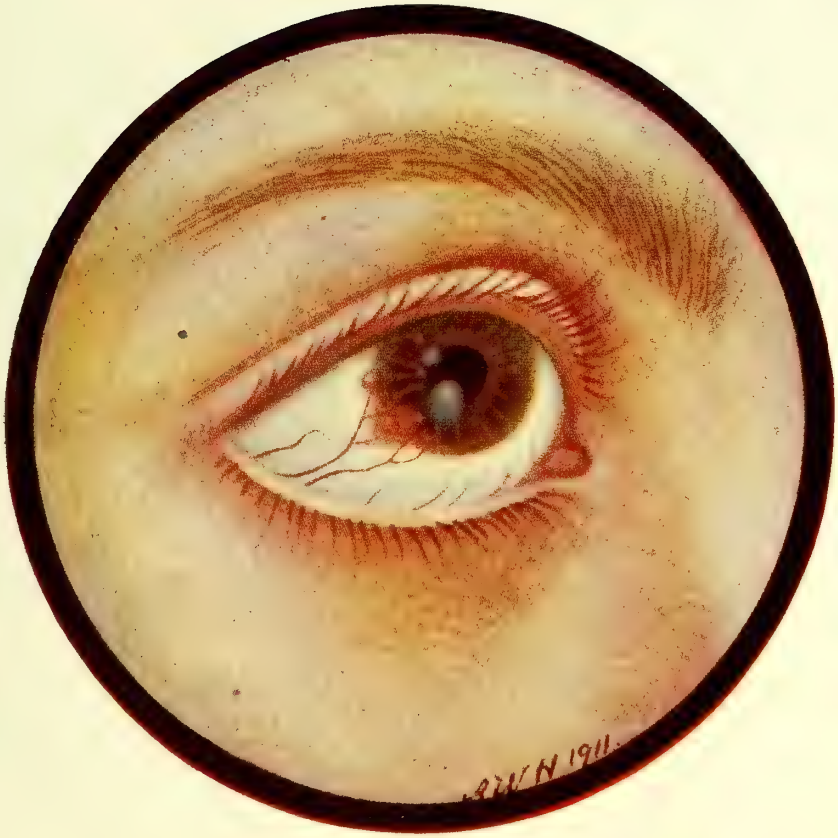


Fig. 1.

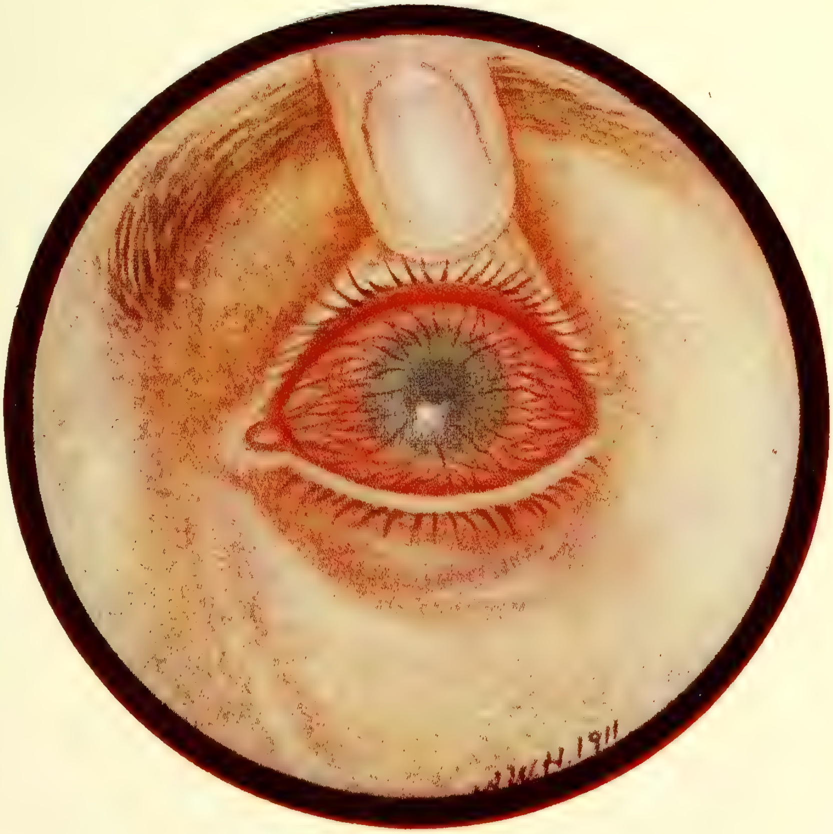


Fig. 2.

as in other connective tissues. The fixed connective tissue cells, here the corneal corpuscles, divide and form masses of nucleated spindle-shaped cells, over which the epithelium grows and is lifted to its normal level. The nuclei and vessels gradually disappear, and a mass of fibrous tissue is formed. The fibres are not arranged regularly like the normal lamellæ, so that they refract the light in various directions: the scar is, therefore, more or less opaque according to its thickness. If it is very large and dense some of the larger vessels persist permanently; the smaller ones disappear. Bowman's membrane is never regenerated, and if it has been destroyed, as is the case in all but very superficial abrasions, some degree of permanent opacity remains.

During the progressive stage there is lacrymation, photophobia, and pain, owing to the exposure of the fibrils of the ophthalmic division of the fifth nerve. Some of the toxins elaborated by the bacteria diffuse through the cornea into the anterior chamber, just as atropin does when instilled into the conjunctival sac. Here they exert an irritative effect upon the vessels of the iris and ciliary body, so that hyperæmia of the iris, with or without definite ciliary injection, occurs. The irritation may be so great that leucocytosis takes place, and polymorphonuclear leucocytes are poured out by the vessels of the iris and ciliary processes. They pass into the aqueous and gravitate to the bottom of the anterior chamber, where they form an *hypopyon* (Fig. 125).

There are several important facts about hypopyon which must be borne in mind. The pus cells do not come from the cornea, as was once thought. This is proved by the following facts: (1) Descemet's membrane is impermeable to leucocytes, though fluids readily pass through it; (2) the cells sometimes contain pigment granules, obviously derived from the uveal tract; (3) if the ulcer has not perforated the hypopyon is sterile. The last fact is of the greatest importance, both theoretically and practically. It shows that the leucocytosis is due to toxins, not to actual invasion of bacteria, which, indeed, are as incapable of passing through the intact Descemet's membrane as are leucocytes. It accounts for the ease and rapidity with which hypopyon is often absorbed : it may develop in an hour or two, rapidly disappear, and as readily reappear. Such hypopyons are very fluid, always moving to the lowest part of the anterior chamber if the position of the patient's head is changed. The fact that the hypopyon is sterile has great practical importance—it is unnecessary to remove the pus, as is the rule in all other parts of the body; if the ulcerative process can be stopped the hypopyon will be absorbed.

The hypopyon may be so small that it is scarcely visible, being hidden behind the rim of sclera which overlaps the cornea. It may reach half way up the iris, having a flat upper surface in accordance with the laws of gravity. It may fill the anterior chamber, wholly obscuring the iris. The larger hypopyons are usually less fluid, owing to the formation of a fibrinous network which imprisons the leucocytes in its meshes. Such hypopyons are much less readily absorbed, and it may be necessary or advisable to evacuate them.

The scar tissue which replaces the destroyed portions of the cornea usually fills in the gap exactly, so that the surface is level. If it is thin the resulting opacity is slight and is called a *nebula* (Plate V., Fig. 1); if rather more dense it is sometimes called a *macula;* if very dense and white it is called a *leucoma.* A thin, diffuse nebula covering the pupillary area interferes more with vision than a strictly localised dense leucoma, so long as the latter does not block the whole pupillary area. The reason is that the leucoma stops all the light which falls upon it

so that the surface is flattened or even indented. Such corneal *facets* can only be seen by carefully examining the corneal reflex (*vide* p. 100), but they cause considerable defect of visual acuity.

From the same cause—deficiency of scar tissue—the cornea may be markedly thinner at the site of the ulcer than elsewhere. The scar may then bulge above the surface, owing to ineffectual resistance to the normal intraocular pressure. As the cicatrix becomes consolidated the bulging may disappear, or it may remain permanently as an *ectatic cicatrix* (keratectasia from ulcer).

Some ulcers, especially those due to the pneumococcus and septic organisms, extend rapidly in depth. There is then grave danger of perforation. The whole thickness of the cornea except Descemet's membrane and a few corneal lamellæ may be destroyed. Descemet's membrane, like other elastic membranes, offers great resistance to inflammatory processes. It is, however, unable alone to support the intraocular pressure: it therefore becomes protruded through the ulcer, appearing upon the surface as a transparent vesicle, which is called a *keratocele.* This may persist, surrounded by a white cicatricial ring, or it may eventually rupture.

Perforation and its effects.—When an ulcer perforates the aqueous suddenly escapes and the intraocular pressure sinks to zero, *i.e.*, to the atmospheric pressure. The iris and lens are driven forwards into contact with the back of the cornea.

The effect of perforation upon the nutrition of the cornea is good: owing to the diminution of intraocular pressure the diffusion of lymph through the cornea is facilitated. Ulceration usually ceases, pain is alleviated, and cicatrisation proceeds rapidly. The complications which attend perforation are however of extreme danger to sight and

even to the preservation of the eye. These complications vary according to the position and size of the perforation.

Usually the perforation takes place opposite some part of the iris, which therefore lines the aperture when the aqueous escapes. The iris becomes gummed down to the opening by lymph, which gradually organises, and an *anterior synechia* is formed. The blocking of the perforation with iris allows the anterior chamber to be re-formed, fresh aqueous being rapidly secreted.

The aqueous often escapes very quickly owing to some sudden exertion on the part of the patient, *e.g.*, coughing, sneezing, straining at stool, or spasm of the orbicularis. Any such sudden exertion causes a rise in general blood pressure, which at once manifests itself by a rise in intraocular tension. The weak floor of the ulcer is unable to support the sudden strain and gives way. In such a case, especially if the perforation is large, a portion of the iris is carried not only into the opening but through it, and a *prolapse of iris* is produced. The prolapse may not include the pupillary margin, in which case it is hemispherical : or the pupillary margin may also prolapse, a tag of iris lying free upon the cornea. In either case the colour of the iris soon becomes obscured by the deposition of grey or yellow lymph upon the surface. In large prolapses the stroma becomes thinned and the black retinal pigment epithelium is thrown into relief.

Sometimes the whole cornea sloughs, with the exception of a narrow rim at the margin, and *total prolapse of iris* occurs. The pupil usually becomes blocked with exudate, and a false cornea is formed, consisting of iris covered by lymph.

If the perforation takes place very suddenly the suspensory ligament of the lens is much stretched. It may rupture partially, causing tilting or dislocation of the lens, or wholly, so that the lens may be expelled through the perforation.

If prolapse of iris has occurred cicatrisation may still progress. The lymph which covers the prolapse or pseudo-cornea becomes organised, and forms a thin layer of connective tissue over which the conjunctival or corneal epithelium rapidly grows. The contraction of the bands of fibrous tissue tend to flatten the protruding prolapse or pseudo-cornea. It rarely, however, becomes quite flat; more commonly the iris and cicatricial tissue are too weak to support the restored intraocular pressure, which is often increased, owing to the advance in position of the iris (*vide* p. 307). The cicatrix tends therefore to become ectatic, and such an ectatic cicatrix in which the iris is incarcerated is called an *anterior staphyloma* (Fig. 111). If the prolapse of iris is partial the resulting staphyloma will be partial; if total, a total staphyloma will ensue. The bands of scar tissue on the staphyloma vary in breadth and thickness, producing a lobulated surface, hence the name (*σταφυλή*, a bunch of grapes).

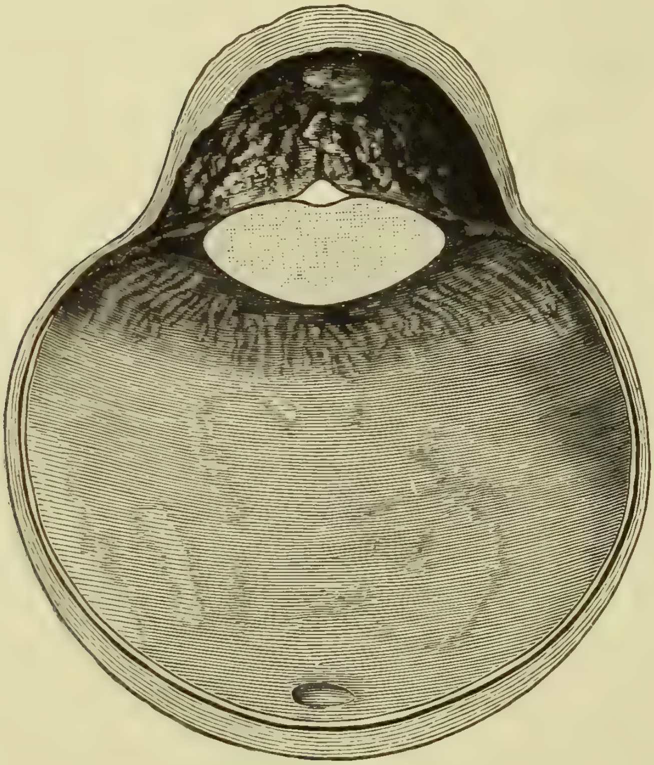


FIG. 111.—Anterior staphyloma, showing also an anterior capsular (pyramidal) cataract. (R. L. O. H. Museum.)

If the perforation happens to be opposite the pupil it cannot be covered with iris. The pupil often becomes adherent to the margin, and the aperture becomes filled with exudate. The anterior chamber is then re-formed very slowly: the lens remains long in contact with the ulcer, and permanent opacity may occur in it—*anterior capsular cataract* (Fig. 111). As the anterior chamber re-forms the exudate filling the opening is submitted to strain. It frequently ruptures, especially if the patient is restless. This process may be repeated again and again, so that the opening may become permanent—*corneal fistula.*

The sudden reduction of intraocular pressure when the preforation occurs removes support from all the intraocular blood vessels. They become dilated and may rupture, *intraocular hæmorrhage* taking place. The retinal vessels may rupture, causing vitreous hæmorrhage, or the choroidal, causing subretinal or subchoroidal hæmorrhage. It may be so profuse that the contents of the globe are extruded with the outflowing blood: indeed in very rare cases the hæmorrhage may endanger life, for it is most likely to occur in old people with atheromatous vessels.

Finally, the organisms which have caused the ulceration of the cornea may gain access to the interior of the eye as the result of perforation, the vitreous acting as an excellent culture medium. *Purulent irido-cyclitis* or even *panophthalmitis* may thus be set up, a result especially prone to occur in gonorrhœal ophthalmia and in hypopyon ulcer (*q.v.*).

Treatment of Uncomplicated Ulcers.—Cleanliness, heat, rest, and protection are the fundamental principles of the treatment of corneal ulcers. Surgical cleanliness is the principle which should regulate the use of lotions; heat is employed to prevent stasis and encourage repair; local rest is attained by the use of atropin; rest and protection from deleterious external agencies are aimed at in the use of bandages.

The ordinary treatment of a simple uncomplicated ulcer is as follows. The conjunctival sac is washed out carefully three or more times a day with a considerable quantity of a mild antiseptic lotion, which should be used as hot as can be borne comfortably (*vide* p. 178). It acts principally by washing away secretions and necrotic material, which carry with them many of the organisms and their toxins. It is impossible to apply antiseptics sufficiently strong to kill the organisms, hence it is of little importance whether weak sublimate lotion (1 in 8000) or simple boric lotion be used.

After each irrigation a drop of 1 per cent. atropin solution or a small lump of 1 per cent. atropin ointment is introduced between the lids.

A protective bandage is then applied. It consists of a pad of sterile gamgee tissue, or a layer of cyanide gauze covered by a pad of cotton wool, kept in place by a bandage, firmly but not tightly applied. A simple tie bandage suffices. This is of sufficient length to pass round the head and tie behind. It passes obliquely above the sound eye, over the ulcerated eye, and under the ear of the side of the affected eye, where the bandage is given a single turn; the ends are tied just above the occipital protuberance.

This treatment suffices for mild cases.

In more severe cases hot fomentations should be applied in the intervals between bathing with lotion, which should be done more frequently—every three or four hours. The compresses should be made of large round pads of plain or boric lint, on one surface of which gutta-percha tissue is sewn. The compresses are placed in a cloth and immersed in boiling water; by keeping the ends of the cloth out of the water and turning them in opposite directions the excess of the water is wrung out without scalding the fingers. The compress is applied as hot as can be borne.

It is at once covered with a large pad of hot cotton wool, and bandaged into position.

Atropin has a twofold function in the treatment of corneal ulcers. In the first place it keeps the eye at rest by paralysing the intrinsic muscles, both the sphincter iridis and ciliary muscle. In the second place it prevents most of the dangerous results of iritis (*vide* p. 282). Corneal ulcers are always accompanied by more or less iridic and ciliary hyperæmia, and actual inflammation often occurs.

Eserin has been recommended instead of atropin in the treatment of some ulcers. It has been held that prolapse is less likely to occur when a peripheral ulcer perforates if the pupil is contracted. This is a fallacy. Even with complete dilatation under atropin the pupil at once contracts when the aqueous escapes. The objections to eserin are that it prevents rest by keeping the sphincter iridis and ciliary muscle in a state of tonic contraction, that it irritates the iris and tends to increase iritis, with consequently greater risk of the formation of posterior synechiæ, and that it causes discomfort or even pain in the eye. It is never to be used for a simple ulcer, though it may have beneficial effects in special chronic types (*vide* p. 252).

Any contributory cause for ulceration must of course receive attention. Prominent among such causes are conjunctival conditions and general malnutrition. Thus, the ulcers associated with trachomatous pannus will not heal if the lids are neglected (*vide* p. 205).

In purulent conjunctivitis and trachoma the lids should be painted with silver nitrate, even during the progressive stage. The copper stick must not be used in trachoma, owing to the irritative effect upon the cornea. The presence of much conjunctival discharge is a contraindication to the use of a bandage; the benefit derived from it is more than counteracted by the retention of secretions (*vide* p. 179). It must be replaced by a shade.

To restrain children from touching their bandages a straight splint may be applied to the front of the arm, reaching a little beyond the elbow, thus preventing flexion.

In debilitated adults or old people and marasmic children the building up of the constitution by good food, fresh air, and tonics is often more important than the treatment of the local condition.

When cicatrisation is complete and all irritative signs have passed off an attempt must be made to render the scar as transparent as possible. The results are usually disappointing, but cicatrices clear considerably in young patients, and in many others a gratifying improvement may be noticed in the course of months or years. Stimulating treatment is indicated, beginning with weak irritants and passing cautiously to stronger. Insufflations of finely powdered calomel may be used first. If it is well borne dilute yellow oxide of mercury ointment is employed. A small lump of the ointment, gr. iv. to ℥ i., is placed in the conjunctival sac and rubbed in gently by rotatory movements of the upper lid by means of the finger. The massage with the lid should be employed three times a day for periods of 5 to 10 minutes. If it is not resented stronger ointment, up to gr. xvi. to ℥ i., is used. As the eye becomes accustomed to one form of irritation it is well to change the drug from time to time. Dionin, 5 to 10 per cent., may be added to the ointment, or used in ~~10 to 15 per cent.~~ solution. On application, especially for the first few times, it causes great œdema of the conjunctiva and a burning sensation. The surgeon should make the first application, as the patient is often alarmed at its severity. The stimulation of the blood and lymph flow induced by this drug is undoubtedly beneficial.

In very intractable cases the same effect may be produced by subconjunctival injections of 2 to 10 per cent.

~~5670~~

(after instillation of cocaine)

Keratoplasty, the excision of a disc of scarred cornea ~~[illegible]~~ with a trephine, & its replacement by a disc of clear cornea from a rabbit's or human eye, is practically never successful. The new tissue rapidly becomes opaque.

sodium chloride solution. Ten to fifteen minims of sterile solution are injected under the bulbar conjunctiva as far as possible behind the upper part of the limbus. The pain, which may be severe, is diminished by the addition of 2 per cent. cocain, or 0·1 per cent. acoin to the solution. The injections should not be repeated more than once a week.

Old, degenerated, often calcareous cicatrices are best left alone, since they are liable to break down and form very dangerous ulcers, owing to the lack of resistance in the scar tissue.

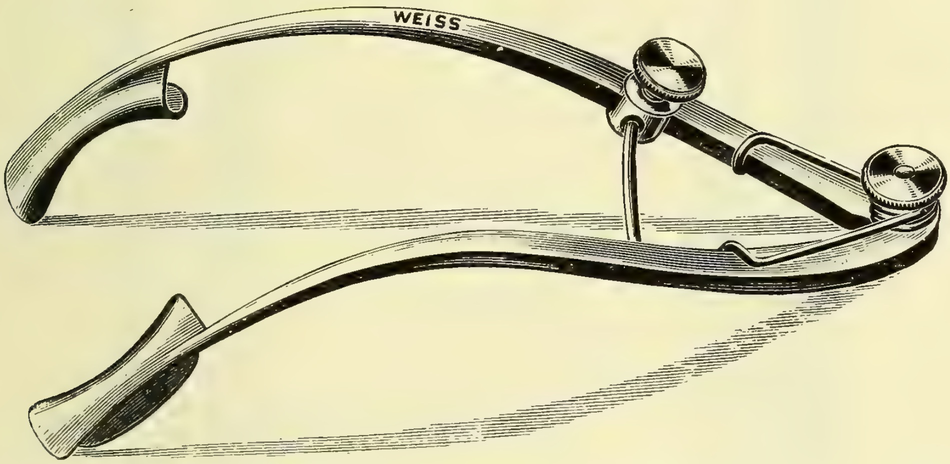


FIG. 112.—Lang's speculum. This form is preferable to the ordinary type, as it keeps the lashes out of the field of operation.

If a small dense leucoma covers the pupillary area vision may be much improved by an optical iridectomy (Chap. XXII.).

Some improvement in appearance may be obtained by tattooing dense leucomata. It is only suitable for firm smooth scars in perfectly quiet eyes, and is even then not without danger. Indian ink is tattooed into the scar with a grooved needle, under cocain, and with thorough antiseptic precautions. The eye must not be held with fixation forceps since the punctures in the conjunctiva will be tattooed: smooth forceps must be used. More justifiable is the tattooing of small central nebulæ; it has the effect of cutting off

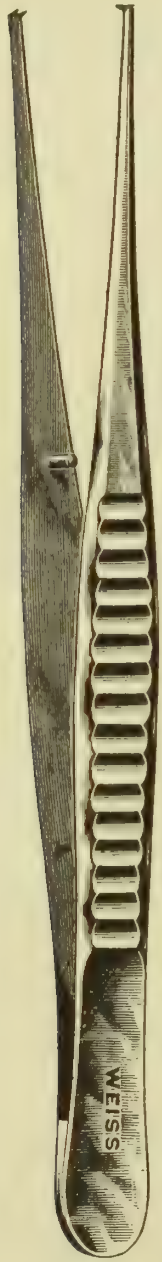


Fig. 113.

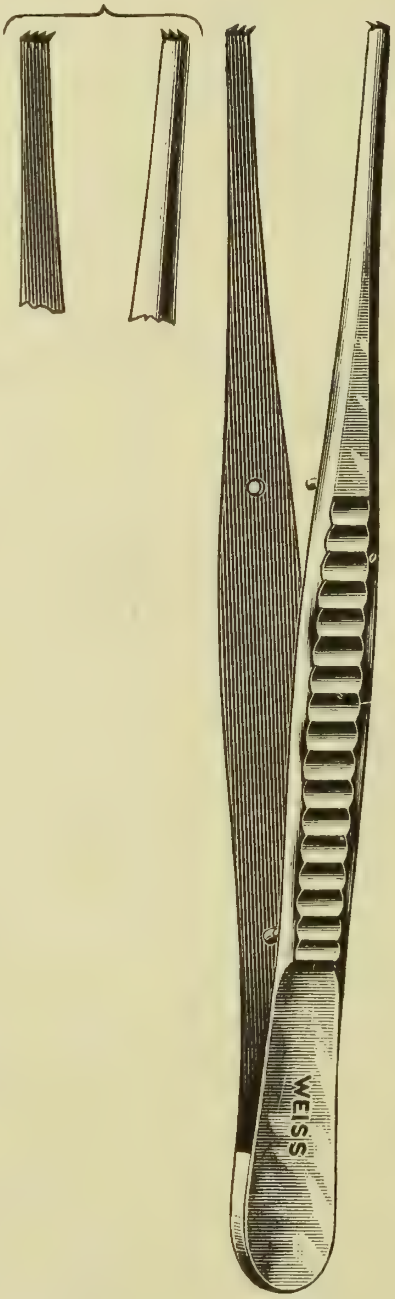


Fig. 114.

Fig. 113.—Ordinary fixation forceps. Fig. 114.—Claw fixation forceps. The latter should be used only when a particularly firm grip of the episcleral tissue is desired, *e.g.*, in operating upon an unsteady patient under cocain.

Or none at all.

the irregularly refracted rays, so that vision is improved (*vide* p. 227).

Treatment of Complicated Ulcers.—If perforation is imminent special means must be adopted to prevent it. The patient should be confined to bed, and laxatives given.

It has already been pointed out that perforation improves the nutrition of the cornea. Perforation may sometimes be anticipated with advantage by *paracentesis.* By this procedure the aqueous is evacuated slowly, and the more dangerous results of perforation may be avoided. Another indication for paracentesis is extreme pain.

Paracentesis may be performed through the floor of the ulcer or just inside the periphery of the cornea. When the aqueous has escaped and the inflamed iris comes in contract with the cornea the most acute pain is felt. If, therefore, the patient is very nervous, a general anæsthetic should be used, but it is to be avoided if possible on account of the straining and vomiting which may attend its administration. Whenever possible the eye is thoroughly cocained by instilling one drop of a 2 per cent. solution every five minutes for a quarter of an hour, the lids being closed during the intervals.

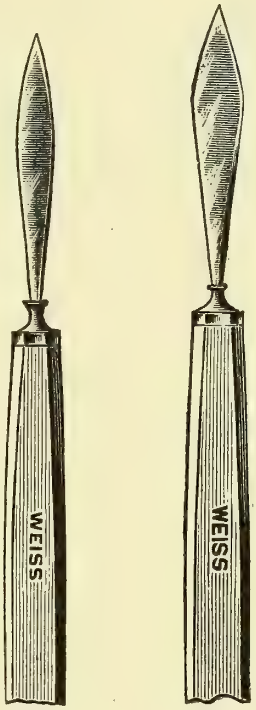


FIG. 115. FIG. 116.

Broad needles.

The patient lies upon his back upon the operating table. The conjunctival sac is washed out with warm boric lotion or saline. The speculum (Fig. 112) is inserted, and the eye is fixed with fixation forceps (Figs. 113, 114) by taking up a fold of conjunctiva at a convenient spot close to the corneal margin. The points of the forceps should be pressed well into the conjunctiva so as to include the episcleral tissue, otherwise they are liable to tear the conjunctiva if much traction is exerted, as by an involuntary movement of the patient. The incision is made with a broad needle (Figs. 115, 116), preferably one bent on the flat, or a keratome (Fig. 117), or a paracentesis needle (Fig. 118). If the floor of the ulcer is to be incised the point is inserted here so that the blade makes an angle of about 45° with the cornea. Directly it is pushed through the floor the plane of the blade is altered so that it lies against the back of the cornea; if this is not done there is imminent danger of wounding the lens. The instrument is pushed on until the incision is sufficiently long. It is then very slowly withdrawn, so that the aqueous may flow off very gradually. If the aqueous escapes suddenly the lens may be wounded, intraocular hæmorrhage may occur, or the iris may prolapse. If the last misfortune occur the prolapse must be excised (*vide* p. 240). If the operation is performed well, probably little aqueous will escape. The spatula (Fig. 119) is then applied to the edge of the wound which is nearer to the corneal margin, and this lip

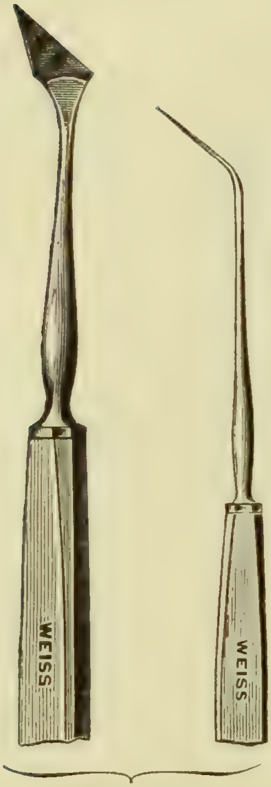


FIG. 117.—Keratome.

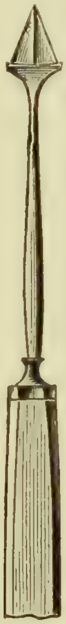


FIG. 118.—Desmarres' paracentesis needle.

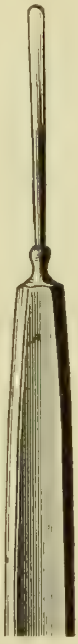


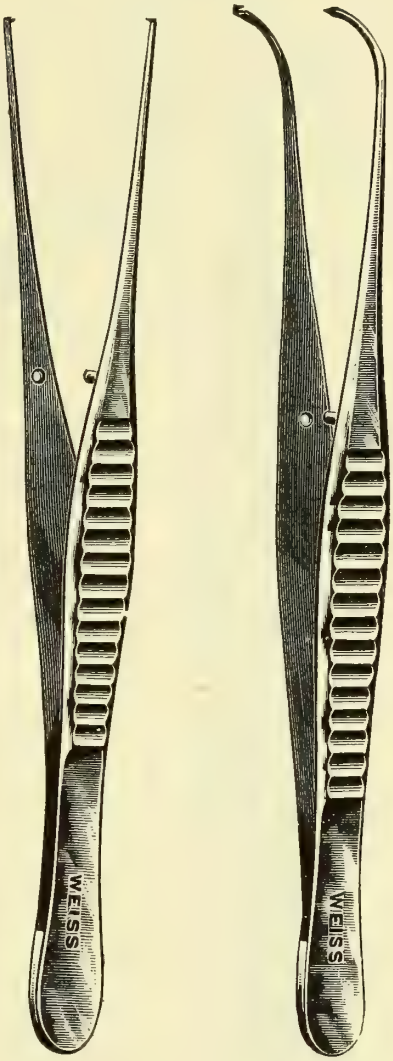
FIG. 119.—Spatula.

is gently depressed. The aqueous then escapes slowly and with a minimum disturbance to the eye. The aqueous can be evacuated on the following day by simply opening the wound with the spatula and depressing the lip.

If the incision is made near the periphery of the cornea it should be 1 to 2 mm. inside the lower margin, especially if there is an hypopyon present. The keratome is then entered in the plane of the iris, and its direction changed as before as soon as the point is seen to be inside the anterior chamber.

In deep ulcers, such as are liable to perforate, the removal of necrotic material may be hastened by scraping the floor with a spatula, or the ulcer may be cauterised (*vide* p. 246). If the actual cautery is used it may be made deliberately to perforate the centre of the floor of the ulcer, so that the aqueous may escape and better conditions of nutrition be set up. This procedure can only be recommended in special cases.

Another procedure is to scrape the floor of the ulcer and then to cover it with a flap of conjunctiva. The conjunctiva is separated from the limbus near the ulcer. A second incision is made with scissors parallel to the first, so that a strip of conjunctiva rather wider than the breadth of the ulcer is separated from the globe but



FULL SIZE FIG. 120. FULL SIZ FIG. 121.

Iris forceps, straight and bent.

remains attached at the two ends. This is then shifted on to the cornea so as to cover the ulcer. The wound in the bulbar conjunctiva may be closed by a stitch. The lids are then carefully lifted over the strip, so as not to displace it, and the eye is bandaged.

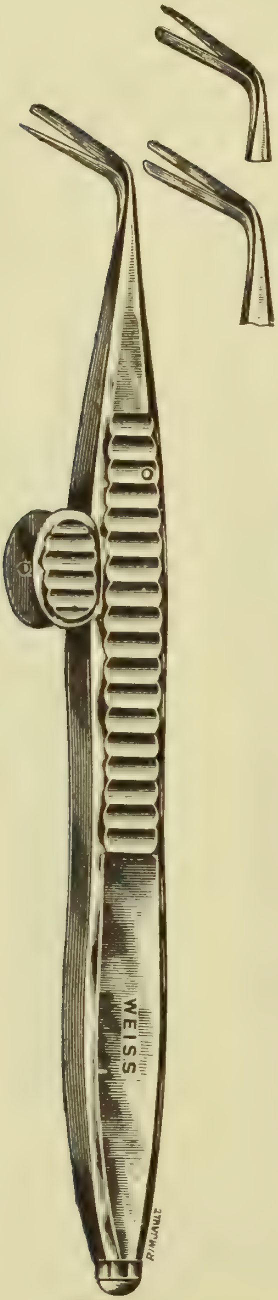


Fig. 122.—de Wecker's scissors. They should be blunt-pointed for iridectomy, one sharp-pointed for iridotomy.

If perforation has occurred the treatment depends upon its size and situation. If it is small or in the pupillary area prolapse of iris is not to be feared. Rest in bed, atropin, and a firmly applied bandage suffice: all forced expiration—blowing the nose, coughing, &c.—must be avoided. A sneeze can often be inhibited by firm pressure with the finger upon the middle of the upper lip close to the nose. If a small perforation is over the iris adhesion to the cornea usually occurs. It may become detached when the anterior chamber re-forms, or may be drawn out into a fine thread. No special treatment is required.

If prolapse of iris has occurred it must be excised. No attempt should be made to replace the prolapse in these cases because the iris has become soiled with pus and replacement may result in infection of the interior of the eye and panophthalmitis.

Iridectomy of prolapsed iris is performed as follows. Instruments required: speculum, fixation forceps,

l, being retained in place by a stitch across the back [illegible], thus keeping
it somewhat stretched.

two pairs of iris forceps (Figs. 120, 121), de Wecker's scissors (Fig. 122), iris repositor (Fig. 123).

If the patient is a child or highly excitable, a general anæsthetic is used, otherwise cocain suffices (*vide* p. 237). The conjunctival sac is washed out (*vide* p. 178). The speculum is inserted, and the eye fixed with fixation forceps held in the left hand. The iris repositor is passed into the wound between the iris and the cornea, with a view to freeing any adhesion. The longer the prolapse has existed the firmer will be the adhesion of the iris to the cornea. It may be impossible to free it, and in this case effectual iridectomy cannot be performed. Having freed the iris as much as possible the fixation forceps are handed over to an assistant. The prolapse is seized with iris forceps held in the right hand, as close to the cornea as possible, and drawn well out from the wound. The second pair of iris forceps, held in the left hand, is then applied again as near the cornea as possible, and the iris drawn still further out. (Capsule forceps (Fig. 124) are very good for this purpose.) De Wecker's scissors are then taken in the right hand, and the iris is cut off close to the cornea. If the operation has been successfully performed the stump of iris retracts into the anterior chamber and is quite free from the wound. Atropin is instilled, and a pad and bandage applied.

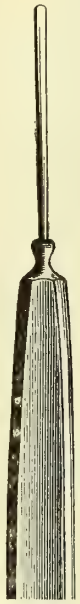


FIG. 123.—Iris repositor, made of silver; it can be bent to any required angle.

It is to be noted here that the iris is extremely ductile; it can be dragged out much farther than might be expected, and it must be dragged out as far as possible in order that the incision may be through clean iris tissue, all the soiled part being removed. Some operators prefer to retain the fixation forceps in the left hand throughout, drawing out the iris with iris forceps in the right hand. In this case the assistant cuts off the prolapse. The method has the advantage that any sudden movement of the eye may be counteracted or followed by co-ordinated movements of the two hands of the same individual. Such sudden jerks have been known to drag the whole iris out of the wound, since it tears away at the thinnest part, viz., near the ciliary border. In ordinary cases the greatest danger is that of wounding the lens. A conjunctival flap may be used after excision of the prolapse (*vide* p. 239).

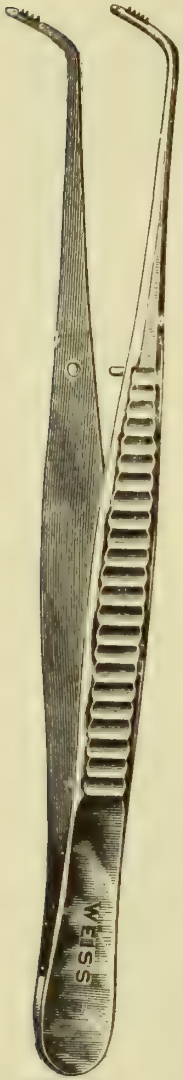


FIG. 124. — Couper's capsule forceps.

Iridectomy of prolapsed iris is only possible within the first few days, before adhesion has become firm. It is not to be performed after this has occurred, nor in the case of very large prolapses.

In very large prolapses there is much bulging and the base is often constricted. Every attempt should then be directed to obtaining a flat cicatrix. In addition to rest in bed and the means already advised a pressure bandage must be applied for a prolonged period. A pressure bandage differs from an ordinary protective bandage only in that the space around the eye is packed carefully with cotton wool to the level of the nose and that considerable pressure is exerted in applying the bandage.

Keratocele is treated first by rest and a pressure bandage. If this fails the vesicle may be punctured, and the case treated like a perforated ulcer.

Fistula of the cornea is treated first like a perforated ulcer. If this treatment fails the edges of the fistula must

there is
L9. the latter, perhaps, ~~a great~~ [illegible] effect on [illegible] in the opinion that [illegible], will [illegible] from [illegible]
a permanent [illegible]
[illegible] [illegible]ing.

and the ulcer is then of a very characteristic type, and has been called *ulcus serpens* from its tendency to travel over the cornea in a serpiginous fashion.

The typical ulcus serpens is a greyish-white or yellowish disc near the centre of the cornea (Plate VI., Fig. 1). The opacity is greater at the edges than at the centre and is particularly well marked in one special direction. A cloudy grey area, made up of fine lines, surrounds the disc, but is also more marked in the same direction. The whole of the cornea may be lustreless or hazy. There is violent iritis, and the aqueous is cloudy or there may be a definite hypopyon. The lids are slightly œdematous and there is conjunctival and ciliary congestion. The subjective symptoms at the early stage are pain in the eye and brow, and a variable amount of photophobia.

The ulcer increases in size and depth. On the side of the densest infiltration, which often looks like a yellow crescent, the tissues break down and the ulcer spreads; on the other side it may be undergoing simultaneous cicatrisation. In this manner it travels forwards. Meanwhile the hypopyon has become more evident, but it may vary in size from hour to hour (*vide* p. 226).

If left to pursue its natural course the hypopyon will increase and become fibrinous, the ulcer will perforate, usually forming a large opening through which the iris prolapses. The whole cornea, except the narrow rim nourished by the corneal loops (Plate II.) may necrose, and panophthalmitis destroy the eye. In other cases an extremely dense cicatrix in which the iris is incarcerated (*adherent leucoma*) destroys sight. This may be flat or ectatic (anterior staphyloma). Sometimes the iris is bound down to the lens before perforation occurs. In such cases there are posterior synechiæ, which may be annular or total (*vide* p. 287), and the pupil may be blocked by exudates which organise into fibrous tissue (occlusion of the pupil).

PLATE VI. (*To face p.* 244.)

Fig. 1.—Ulcus serpens, with crescentic infiltrated advancing border above. There was no hypopyon when the figure was drawn. (From a drawing by Dr. S. H. Habershon).

Fig. 2.—Iritis, with irregular pupil and ring synechia, causing bulging forwards of the iris (" iris bombé ").

Fig. 3.—Persistent pupillary membrane. Note the origin of the strands from the position of the minor arterial circle.

Fig. 4.—Persistent pupillary membrane. The strands are adherent to the lens capsule, which has finely granular pigment upon its surface

PLATE VI.

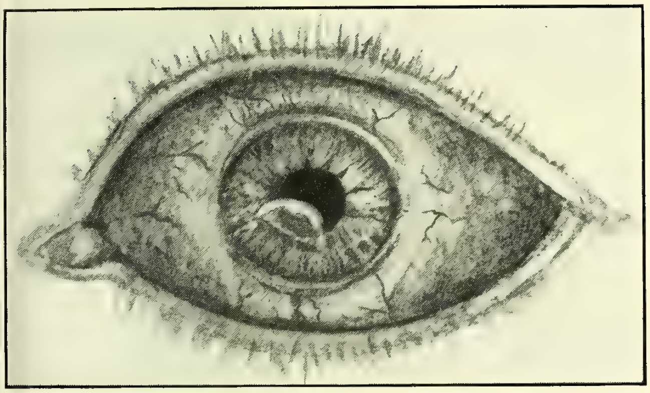


FIG. 1.

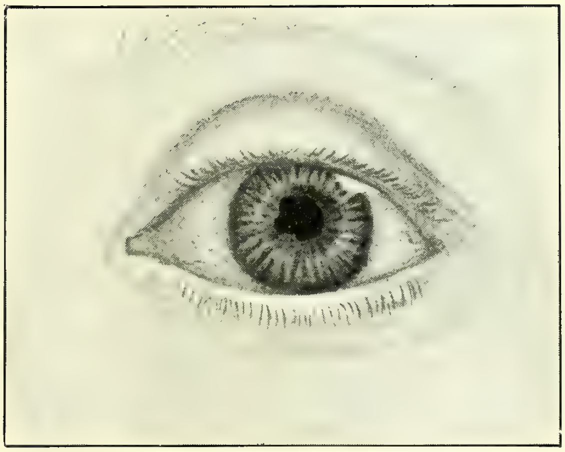


FIG. 2.

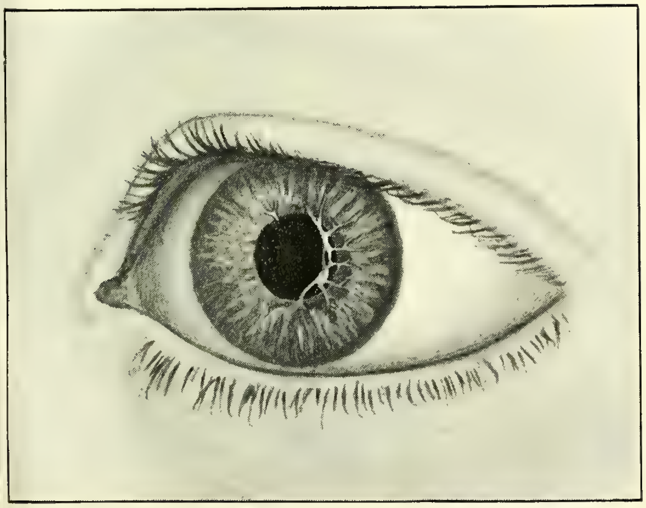


FIG. 3.

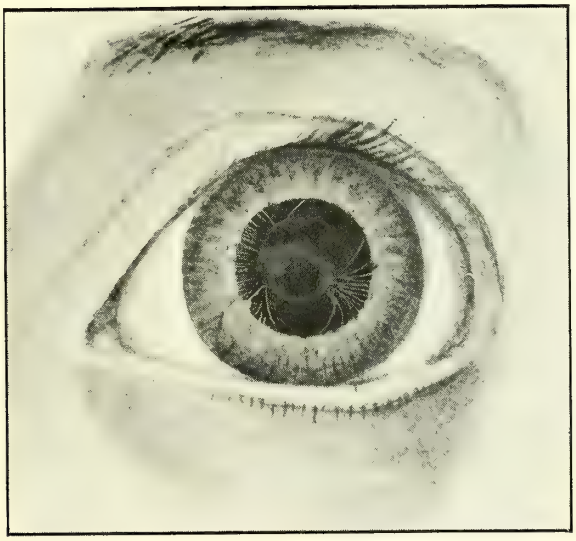


FIG. 4.

/ ¶ The indolent type of hypopyon ulcer is often due to the diplobacillus of Morax & Axenfeld, or to the allied diplobacillus liquefaciens of Petit. It usually commences as a central grey infiltration, which ~~filament~~ develops into an ulcer covered by a grey membrane & surrounded by radiating grey striae. It spreads in all directions, but does not show the same tendency as the pneumococcus ulcer to spread in depth. It can only be diagnosed with certainty by bacteriological examination.

As already stated,
/ A relatively mild form is due to the Morax Axenfeld diplobacillus ~~[illegible]~~
~~[illegible]~~

Though hypopyon ulcer occurs sometimes in children it never assumes the typical form of an ulcus serpens. In them and in some cases in adults the serpiginous character of the ulcer is not apparent, but it is distinguished by its great tendency to extend in depth, so that perforation readily occurs. On the whole, such ulcers have a milder course than the ulcus serpens, and this is especially the case in children. It is doubtless due partly to the fact that less virulent organisms are at work, especially applicable to adult cases, and partly to greater resistance of the tissues, especially applicable to children.

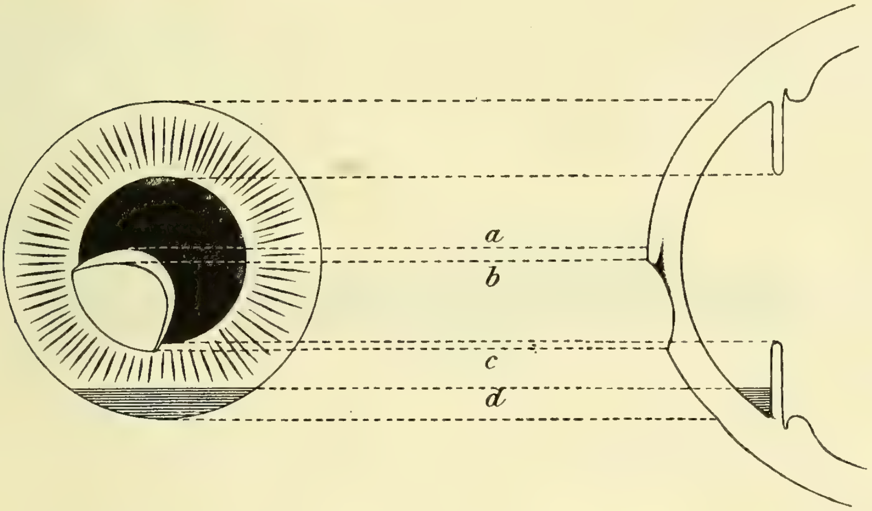


FIG. 125.—Diagram of hypopyon ulcer. *a*—*b*, advancing infiltrated border; *b*—*c*, ulcerated surface; *d*, upper level of hypopyon.

Pathology.—The ulcus serpens is due to the pneumococcus, either alone or mixed with other organisms. There is no doubt that the essential features are caused by the pneumococcus alone. A variety of organisms—staphylococci, streptococci, gonococci, &c.—have been found in atypical hypopyon ulcers.

Anatomically, the ulcus serpens shows at first a depressed surface covered with slough (Fig. 125). The corneal lamellæ around and below the ulcer are separated by masses of polymorphonuclear leucocytes.

In the progressive stage the infiltration is chiefly limited to an area, wedge-shaped in section, corresponding with the yellow crescent. In other parts the edges are clean, and may be covered with epithelium. Often there is infiltration just anterior to Descemet's membrane at a spot exactly opposite the floor of the ulcer, whilst the intervening lamellæ are normal. This fact accounts to some extent for the great tendency to perforation, since the inflammatory process is going on as it were from both surfaces of the cornea.

The hypopyon consists of polymorphonuclear leucocytes massed together in the lower angle. In the later stages they are enmeshed in a network of fibrin. It has been pointed out that the leucocytes are derived from the iris and ciliary processes (*vide* p. 225).

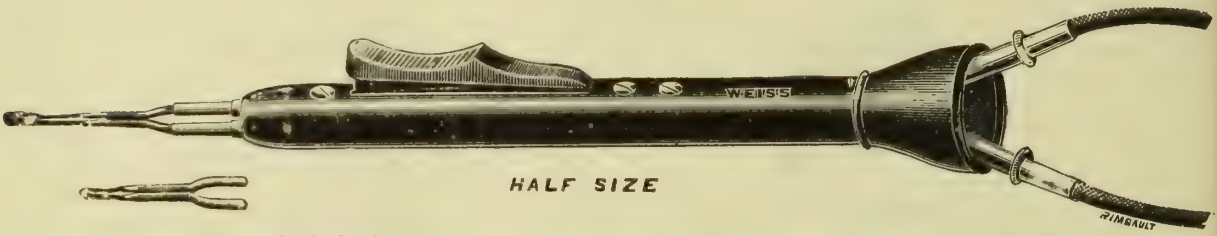


FIG. 126.—Ophthalmic galvano-cautery, which may be worked off the main with a transformer, or off a portable accumulator.

Treatment.—In all cases of hypopyon ulcer in adults treatment must be initiated at once and must be energetic. The first stage is cauterisation of the ulcer. If it is performed skilfully it does no harm and may save the eye.

Cauterisation may be performed with pure carbolic acid or with the actual cautery, the most convenient form of the latter being the galvano-cautery (Fig. 126). In my opinion the latter method, which requires more skill, possesses no advantages and has some disadvantages. Apart from the dangers attending the use of the actual cautery, carbolic acid has the advantage of penetrating a little more deeply than it is actually applied, thus extending

the actual cautery may be used. It has been recommended to heat the ulcer with the cautery without actually touching it; or hot air may be blown on to it from a rubber ball, such as is used by dental surgeons. This treatment is certainly beneficial in some cases.

If these means fail, & especially if the tension of the eye is raised (*vide infra*), yet more drastic measures must be resorted to. (run on) its antiseptic properties more widely: it acts both as a caustic and an antiseptic. No harm is done even if the acid spreads over the normal cornea. Although the parts touched become at once quite white the normal tissues rapidly recover without detriment. The acid must not, however, touch the conjunctiva, otherwise very acute conjunctivitis is set up and adhesion between the lids and globe may occur.

Pure carbolic acid is applied as follows. The patient is seated or lying upon a couch. The ulcer is first stained with fluorescein (2 per cent.), in order that its limits may be more clearly defined. The conjunctival sac is thoroughly cocained (*vide* p. 237). The surgeon stands behind or at the head. With his left hand he separates the lids as in removing a foreign body, steadying the globe at the same time. The ulcer is scraped with a spatula and together with the surrounding cornea is dried with the point of a piece of blotting paper. A wooden match, somewhat pointed, is dipped into the carbolic acid. Care is taken that the wood is thoroughly wet, but has no drop of acid hanging to it which may run over the cornea. The ulcer is then touched over the whole of its surface with the point of the match. If there is sufficient carbolic acid on the match the spot touched becomes white. Special care is taken thoroughly to cauterise the advancing edge of an ulcus serpens, *i.e.*, the part marked by a yellow crescent.

Cauterisation with carbolic acid may be repeated two or three times at intervals of one or two days if the ulcer still progresses. If this treatment, combined with the use in the intervals of mild antisepsic lotions, atropin, and hot compresses, as for less severe ulcers, does not check the progress, yet more drastic measures must be resorted to.

Of these the most important is *paracentesis*. It may be performed as already described, but in the case of hypopyon ulcers what is called *Saemisch's section* offers some advantages. It consists in completely dividing the ulcer from one side to the other, the ends of the incision being in healthy corneal tissue. It must be remembered that if the operation is performed under cocain the most excruciating pain is felt when the iris comes into contact with the cornea. For this reason it is best to use a general anæsthetic.

Saemisch's Section.—Instruments required: speculum, fixation forceps, Graefe knife (Fig. 127), smooth iris forceps; in case the iris should prolapse, the following should also be at hand: two pairs of iris forceps, de Wecker's scissors, iris repositor.

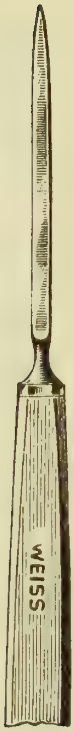


FIG. 127.—Narrow Graefe knife.

After cocaining or anæsthetising, the eye is washed out and the speculum is inserted. The eye is fixed with fixation forceps in the usual manner (*vide* p. 237). The point of the Graefe knife is inserted in healthy cornea just outside the edge of the ulcer, preferably at the advancing part where the yellow crescent is densest. The edge of the knife is directed forwards, so that if the lens advances before the section is complete it will touch the back of the knife and not be wounded. The knife is passed across the anterior chamber until the point is seen beyond the opposite edge of the ulcer. The counter-puncture is made in healthy cornea here, and the knife is pushed on so as to cut out. The aqueous pours out, and carries with it much of the hypopyon. Atropin is instilled, and the eye bandaged.

If the ulcer is very large it is impossible to make the puncture and counter-puncture in healthy cornea. In these cases, too, the knife usually cuts out as it is in the

L (though it was previously used by Guthrie)

¶ If there is a mucocele the lacrymal sac should be excised ~~[illegible]~~ as soon as possible (v. p.).

(4) 1' ¶ Instead of the ordinary antiseptic lotions hydrogen peroxide may be used. Optochin or ethyl hydrocuprein, a quinine derivative, is said to have a specific action on pneumococcic ulcers: a 1% solution is dropped into the eye frequently, or it may be applied locally to the ulcer.

~~[illegible]~~ The Diplobacillus hypopyon ulcers should be treated with zinc salts. ~~[illegible]~~ Zinc sulphate solution (¼–1%) should be used every hour or two, & an ichthyol (1.5%) & zinc sulphate (0.5%) ointment applied to the lids.

The results of treatment of the severe forms of hypopyon ulcer are disappointing. This is largely due to the fact that they are seen too late. In reality it is possible to control the development of pneumococcic ulcers by intravenous injection of an anti-pneumococcic serum, if this be used sufficiently early. This method has been adopted in man, but usually failed. And the cause of failure is the development of secondary glaucoma during the treatment. The patients are usually elderly, & therefore of the same shallow anterior chambers. Apart from the presence of an ulcer one would hesitate to use atropine in such an eye for the dread of causing glaucoma (v. p.). Now the presence of an ulcer, with the accompanying iritis, invites the use of atropine. We are therefore on the horns of a dilemma. The risks of glaucoma from the use of atropine will have to be borne, for atropine at least tends to a beneficial effect in keeping the iris at rest & tends to diminish the iritis, & lessen the hypopyon. The routine use of atropine is therefore justified, but the tension of the eye should be watched much more carefully than is usually done. If the tension rises the effect on the cornea is extremely bad, for it diminishes the lymph flow & therewith the resistance of the tissues to bacterial action. It is indeed a definite indication for prompt paracentesis or Saemisch's section; otherwise the condition will go from bad to worse.

act of passing across the ulcer. If the hypopyon is very fibrinous it may be necessary to pull the coagulum out with the smooth iris forceps.

This procedure improves the conditions of nutrition of the cornea and evacuates the hypopyon. It is not to be advocated in mild or in the early stage of severe cases, but as a last resource it may prove beneficial.

Mycotic Hypopyon Ulcer.—A rare form of hypopyon ulcer due to a fungus, the aspergillus fumigatus, is occasionally met with. In it the slough is dry in appearance, and is surrounded by a yellow line of demarcation, which gradually deepens into a gutter. As the name implies there is an hypopyon. Treatment is the same as for other hypopyon ulcers.

Phlyctenular Keratitis.—It has already been pointed out that phlyctens are commonly found seated upon the limbus. They may also occur within the corneal margin. The fact must be emphasised that the disease is essentially conjunctival, and when the cornea is affected it is the conjunctival element of the cornea, viz., the epithelium and the superficial layers immediately underlying it, which suffers. Phlyctenular keratitis does not necessarily result in ulceration, so that in these cases it is incorrect to classify it as a purulent keratitis, but it is convenient to consider the corneal manifestations of the disease under this heading because the complications and their treatment are similar to those of corneal ulcers in general.

Corneal phlyctens are localised infiltrations of exactly the same nature as conjunctival phlyctens. They cause more pain and reflex blepharospasm (photophobia) than do the conjunctival ones, symptoms which are worst in the morning. They may become absorbed without destruction of the overlying epithelium: in this case they cause no permanent opacity. The tendency for the epithelium to be destroyed or rubbed off is very great (cf. p. 190), and the denuded surface easily becomes infected. In this manner a small superficial ulcer is formed.

The corneal phlycten is a grey nodule, slightly raised above the surface. If the epithelium breaks down and an ulcer is formed the surface becomes covered with polymorphonuclear leucocytes and looks yellow. The subsequent course depends probably upon the nature of the infection and the condition of nutrition of the patient. It may deepen rapidly and even perforate, though this is comparatively uncommon.

A very characteristic form of phlyctenular ulcer is the *fascicular ulcer* (Figs. 68 B, 128). This is a serpiginous ulcer which steadily creeps over the cornea, usually towards the centre, advancing slowly for weeks. It is supplied by a leash of vessels which lie in a shallow gutter and follow the advance of the ulcer. The ulcer starts near the limbus and heals on the peripheral side, whilst the central margin remains grey and infiltrated. As long as this infiltrated crescent is seen the ulcer is progressing. It always remains superficial and never perforates. When healing finally takes place the vessels gradually disappear, but the whole of the track of the ulcer remains as a permanent opacity, densest, however, where the ulcer stops.

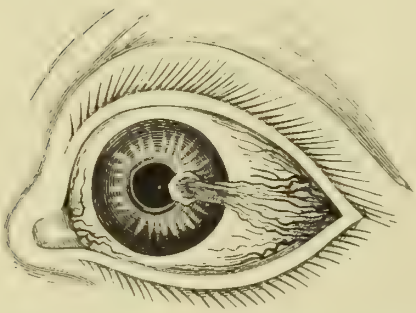


FIG. 128. — Fascicular ulcer, travelling inwards towards the centre of the cornea. (Nettleship.)

The severest cases of phlyctenular keratitis are accompanied by a diffuse deep-lying infiltration. The large greyish area is dotted over with minute spots. The deep infiltration may disappear entirely, or it may become yellow and break down, forming a large ulcer.

Sometimes the phlyctens are so closely packed at the

limbus that they become confluent and may even surround the cornea. If they break down and form a *ring ulcer* an extremely dangerous condition is set up. The nutrition of the whole cornea is endangered, and even if total necrosis does not occur an extensive perforating ulcer may be formed at the margin.

More commonly, however, a continuous infiltration of the limbus leads to the development of superficial vessels at the periphery of the cornea, a condition which is called *phlyctenular pannus* (pannus eczematosus or scrophulosus) (Plate V., Fig. 2). Unlike trachomatous pannus (*q.v.*) it shows no special predilection for the upper part of the cornea. It is thin and not very vascular, and usually undergoes complete resolution, though the course is generally very tedious. It is accompanied by intense blepharospasm.

Treatment of phlyctenular keratitis is the same as that of phlyctenular conjunctivitis (*q.v.*) until ulceration has occurred. In these cases atropin is to be combined with the yellow oxide of mercury ointment. If the latter causes much irritation, or if the ulcer is at all deep, simple atropin ointment should be substituted. The yellow ointment is particularly beneficial in fascicular ulcers, but may fail to stop their progress. The crescentic infiltrate should then be cauterised with pure carbolic acid or the actual cautery, or the vessels may be destroyed with the actual cautery. Pure carbolic does not destroy vessels efficiently, and whenever this is desired the actual cautery must be used. These extreme measures are seldom required in phlyctenular keratitis. If a fascicular ulcer has already reached the centre of the cornea and lies over the pupillary area it is not a bad plan to allow it to progress still farther, because the opacity left by the track of vessels is less dense than that left at the final site of ulceration.

Ring ulcer must be treated by hot compresses, atropin, and a pressure bandage.

Deep ulcers and the scars left by phlyctenular keratitis must be treated on general principles (*vide* p. 232).

Marginal Ulcer. — Apart from the ring ulcers of phlyctenular keratitis ulcers not infrequently occur in this situation in old people, especially in the gouty. They are shallow and little infiltrated, often multiple. Sometimes they heal rapidly, but as rapidly recur, so that the process drags on indefinitely, to the detriment of the patient's health. Frequently the ulcers become vascularised, and the vessels persist. More serious rare forms of deep marginal ulceration also occur in old people, and a very serious form of superficial marginal ulcer is also met with (*vide* p. 258). Marginal ulcers are often accompanied by severe neuralgic pains in the face and head.

Treatment.—The recurrent marginal ulcers of gouty people are best treated by painting the ulcer with weak silver nitrate solution, gr. v. to ℥ i. They often heal up quickly after this application, combined with weak antiseptic lotions. Recurrence, however, can only be prevented, and that with difficulty, by constitutional treatment, which includes the special diets and drugs for gout, as well as fresh air and moderate exercise. The eyes should be protected with smoked glasses. If this treatment fails, and and the ulcers are vascular, destruction of the vessels with the actual cautery is most likely to succeed. Sometimes eserin does good in these cases.

Central Ulcer. — Symmetrical central ulcers of an extremely indolent type are not infrequently met with in badly nourished children. They probably occur here because this part of the cornea is farthest from the nourishing vessels. They are quite superficial, show little infiltration and no vascularisation; they form shallow round pits or facets about 2 mm. in diameter. There is little or no reaction, either in the form of lacrymation or photophobia. They do not spread either superficially or in

⌊ They are sometimes due to the Morax-Axenfeld diplobacillus.

⌊ resembling the phlyctenular ring ulcer, sometimes leading to necrosis of the whole cornea. Chronic serpiginous ulcer (see p. 258) commences at the margin of the cornea.

⌊ The diplobacillary ulcer should be treated with zinc lotion (see "Angular Conjunctivitis", p. 198)

¶ In the deep ring ulcer & old people silver nitrate or the actual cautery may be used. Paracentesis may be employed for avoiding perforation & to [illegible] the sloughing of the cornea. Every attempt should be made to ~~[illegible]~~ build up the constitution by a nutritious diet & tonics.

Generally early in the first year of life.

Both eyes usually become affected. Staphylococci have been found in the cornea & sometimes in the blood; in other cases the pneumococcus was present. Many of the children are syphilitic.

[illegible]

Subcutaneous injections of large quantities of saline solution are ~~good~~. beneficial.

depth, nor do they show any tendency to heal. When they finally heal they often leave permanent clear facets, showing the absence of a proper supply of pabulum during the cicatricial stage. They appear to have nothing in common with phlyctenular keratitis except that both conditions are indications of defective nutrition. They are not uncommonly associated with trachoma.

They sometimes occur outside the centre of the cornea, and may perforate, allowing a knuckle of iris to prolapse. This prolapse should not be cut off, owing to the relatively large gap in the cornea, and the defective powers of repair in the debilitated patient.

Treatment must be directed especially to improving the general nutrition. A few weeks in a convalescent home in the country will effect more than any local treatment. Atropin and boric lotion are used locally. Trachoma, if present, must be suitably treated.

Keratomalacia is a rare disease in England, affecting badly nourished children. The conjunctiva becomes dry and shows xerotic spots (*vide* p. 217). The cornea becomes dull and insensitive; the haze increases and yellow infiltrates form. Finally the whole cornea necroses and may seem to melt away within a few hours. In the rare cases in which the children are old enough to exhibit the symptom the disease commences with night blindness; they are able to see much better in the daytime than in the dusk. The children are usually extremely ill and very frequently die. Owing to their apathetic condition they do not close the lids, so that the cornea is continually exposed.

Treatment must be directed to the general health and environment. The lids should be kept closed under moist warm compresses. The nutrition of the cornea is sometimes benefited by the use of eserin.

Atheromatous Ulcers occur in old dense leucomata, especially such as have undergone degenerative changes resulting in the formation of hyaline fibrous tissue and calcareous deposits. Such scars have little vitality and the deposits act as foreign bodies. They readily succumb to infection, the epithelium being badly nourished. When ulceration once commences it proceeds rapidly and deeply, with little or no effort at repair. Perforation takes place, and is often followed by panophthalmitis.

Treatment.—The eye is frequently blind and disfiguring. In such cases it is well to excise it at once, thus relieving the patient of much unnecessary misery. If it is worth saving the condition must be treated on general principles.

Keratitis e lagophthalmo occurs in eyes insufficiently covered by the lids. The epithelium of the exposed cornea becomes desiccated and the substantia propria hazy. Owing to the drying the epithelium is cast off, and the cornea falls a prey to infective organisms.

The condition is due to any cause which may produce lagophthalmia, *e.g.*, extreme proptosis as in exophthalmic goître or orbital tumour, paralysis of the orbicularis, and so on. The absence of reflex blinking is an important factor, as well as defective closure of the lids during sleep. Patients extremely ill from any disease are liable to this form of keratitis.

Treatment consists in keeping the cornea well covered. In mild cases it is sufficient to bandage the eyes at night. If possible the cause of the exposure must be removed. In the meantime it may be necessary to keep the lids closed with plaster and a bandage, or partially to sew them together (*vide* p. 256).

Neuroparalytic Keratitis occurs in some cases in which the fifth nerve is paralysed. ~~It does not occur~~ in all cases; thus, if the Gasserian ganglion is removed for trigeminal neuralgia with proper precautions only a small proportion of the cases get neuroparalytic keratitis. The disease has

It is relatively rare in nuclear or fascicular lesions within the central
nervous system, unless the facial nerve is simultaneously implicated,
nor does it occur in all cases of peripheral lesion.

~~In nuclear or fascicular lesions within the central nervous system nor~~
~~of peripheral lesion~~

Nor the fifth nerve injected with alcohol

(53)

[On the other hand the importance of reflex closure of the lids is shown by the fact that keratitis occurs in all cases of ~~bilateral~~ paralysis of ~~the~~ both fifth nerves. When only one is affected the conjunctival reflex from the other eye affords protection. Moreover the disease is more likely to occur if there is paresis or paralysis of the orbicularis palpebrarum.

Besides these cases which result from radical treatment for trigeminal neuralgia neuroparalytic keratitis is caused by intracranial tumours, especially gummatous meningitis, & fractures of the skull.

been known since the time of Magendie, and was attributed to special trophic impulses conducted by the nerve. This theory was combated, and the view advanced that the condition depended upon the loss of sensation in the eye. As a result, reflex blinking was more or less abolished, minute foreign bodies were not felt and therefore not removed, abrasions were unnoticed and untended, so that ulceration was readily induced and pathogenic organisms had free play. Neither of these theories satisfactorily accounts for the facts. It will be seen that the disease of the cornea usually has a very characteristic nature, quite different from the ulceration of neglected injuries. It is probable that in some manner not fully understood the disease is due to irritative changes in or about the degenerating nerve, and that mere section or paralysis of the nerve is unable to produce the disease in the absence of such irritative conditions.

The characteristic feature of neuroparalytic keratitis is the desquamation of the corneal epithelium. The surface of the cornea becomes dull, and the epithelium is thrown off, first at the centre, then over the whole surface except a narrow rim at the periphery. The whole of the epithelium may peel off intact. The substantia propria then becomes cloudy and finally yellow, breaking down into a large ulcer, which is usually accompanied by hypopyon. There is no pain, owing to the anæsthesia, but ciliary injection is marked. A large perforation occurs if the case is not speedily treated. In any case the resulting leucoma is generally so large as to destroy useful vision. Relapses are the rule, the healed scar quickly breaking down again, and the whole process being repeated.

After complete removal of the Gasserian ganglion sensation is never regained.

Treatment.—The ordinary treatment of corneal ulcer should be tried as a preliminary, special care being devoted to the protection of the eye with a bandage.

Improvement is often marked, but directly the bandage is relinquished the ulceration starts anew. In these cases it is best to suture the lids together, and to keep them sutured for a long period, only separating them when the conditions of the weather—warmth, absence of high winds, and so on, are favourable. It is usually insufficient to narrow the palpebral aperture by lateral or median tarsorrhaphy, *i.e.*, suturing the lids at the canthi (Fig. 129). Too great an area of cornea is left exposed. It is best to suture them for 8—10 mm. in the middle (central tarsorrhaphy).

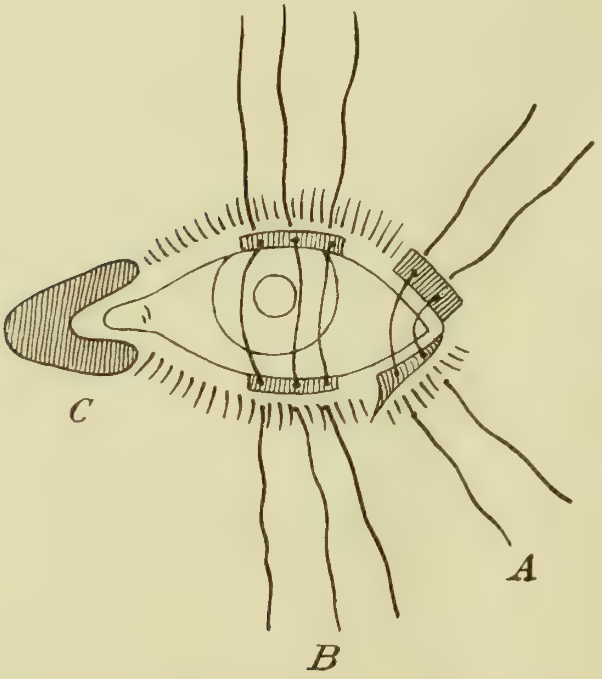


Fig. 129. — Tarsorrhaphy. A, lateral, by Fuchs's method ; B, central ; C, median.

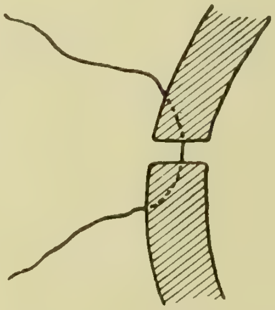


Fig. 130.—Insertion of stitches in central tarsorrhaphy.

No anæsthetic is necessary, since sensation is lost in the conjunctiva and lids. The mucous membrane is dissected up from the margin of the lower lid just posterior to the lashes over a rectangular area about 8—10 mm. long in the middle of the lid. The edge of the upper lid is similarly treated at the corresponding

/ if the ophthalmic branch of the fifth nerve is completely paralysed.

with the cornea [illegible]

Generally only one or two of the ~~[illegible]~~ epithelial blebs [illegible] at a time,
but fresh ones are continually being formed.

/ the disease not infrequently recurs.

position. Two or three sutures are then passed through the skin so that they come out at the posterior edge of the bare surface (Fig. 130), not on the posterior surface of the lid where they would rub against the cornea. After being similarly carried through the skin of the other lid they are tied, and the freshened surfaces are brought into contact. In a few days, if the stitches have not torn out, the lids will be firmly adherent.

In the worst cases the eye is useless, and tends to become a source of perpetual trouble. It is then best to excise it, which may be done without any anæsthetic.

Dendritic Ulcer is the result of herpes febrilis, more rarely of herpes ophthalmicus. The vesicular stage is rarely seen, the epithelial wall of the vesicle being quickly broken. Minute shallow clear facets, like abrasions, are found in the first stage. They may be easily overlooked. They generally cause much pain, lacrymation and blepharospasm. They may spread in all directions, coalescing with others and forming a large shallow ulcer with crenated edges. More often gray striæ extend in one or more directions, increase in length, and send out lateral branches, which are generally knobbed at the ends (Fig. 131). In this manner a dendritic figure, not unlike a liver-wort, is formed. The surface over the infiltrates breaks down, and an extremely irritating and chronic type of ulcer is produced. It is often associated with frontal neuralgia. Such an ulcer may persist in spite of treatment for weeks or months, sending out fresh branches but never extending in depth.

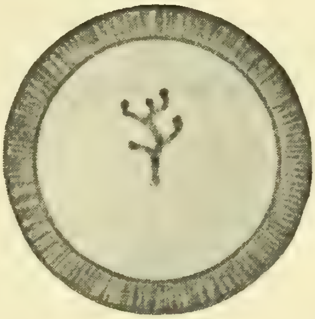


FIG. 131. — Dendritic ulcer, somewhat diagrammatic.

Treatment.—The ulcer should be carefully cauterised with pure carbolic acid. Absolute alcohol has been recommended for the purpose in these cases, but causes much pain after the cocain has ceased to act. If carbolic fails to stop the progress the actual cautery should be used. Atropin, &c., and a pad and bandage are used, but in many cases it is advisable simply to use smoked glasses and get the patient out in the fresh air as much as possible. The general health must not be neglected, especially as the patient often becomes very depressed.

Chronic Serpiginous Ulcer (*Syn.—Rodent Ulcer, Mooren's Ulcer*).—This is a rare superficial marginal ulcer, usually occurring in elderly people, and spreading, if not checked, over the whole cornea. It undermines the epithelium and superficial lamellæ at the advancing border, forming an overhanging edge, which is very characteristic. The base becomes quickly vascularised. It never perforates, but goes on with intermissions for months, until eventually a thin nebula is formed over the whole cornea, and sight is much diminished. Both corneæ are affected, but not always simultaneously.

Treatment.—~~No treatment is of any avail except the actual cautery, and that not invariably.~~ The overhanging edge should be cut off with scissors, and then the whole surface of the ulcer, and especially the margin, should be well cauterised.

Non-suppurative Keratitis.—This occurs in two types, superficial and deep. The superficial forms include some purely symptomatic conditions, such as pannus. Some of them, such as herpes, may lead to the formation of ulcers and pass into the purulent type. The deep forms never suppurate.

Herpes Corneæ.—Herpes of the cornea occurs most commonly in herpes febrilis, more rarely in herpes ophthalmicus.

In herpes febrilis vesicles form upon the cornea quite

Sometimes, for no known reason, eserine is unsuccessful when atropin has failed to produce a good result.

(54)

It commences by one or more grey infiltrations which break down forming small ulcers, which spread & sooner or later coalesce. The ulcer

(55)

There is sometimes iritis, & very rarely a small hypopyon. In about a quarter of the cases [illegible]

The cause is unknown.

(56)

with the actual cautery. A few cases have responded to repeated applications of absolute alcohol to the ulcers. More commonly treatment fails to stop the process, which has even been known to recur in the cicatrised cornea.

[illegible]

[illegible] ~~[illegible]~~ appear the condition may prove very obstinate.

which may be of pustular type or may be due to secondary infection.

(57) The supraorbital, supra-trochlear [illegible] branches are nearly always involved; frequently the nasal branch; only rarely the infraorbital branch. It is very rarely bilateral. There may be pain for a day or two at the onset of the eruption or preceded by severe neuralgic pains. There are no characteristic [illegible] the disease before the ~~many~~ [illegible] the vesicles appear. The ~~[illegible]~~ pain ~~[illegible]~~ sometimes ~~[illegible]~~ [illegible] always, and ceases after the [illegible] of the eruption. The skin of the lid [illegible] may continue for weeks or months [illegible] ~~[illegible]~~ [illegible], the skin affected become ~~[illegible]~~ [illegible] that the disease is often mistaken for erysipelas. The characteristic distribution, [illegible] the sharp limitation of the ~~[illegible]~~ head should [illegible] to one side of the middle line [illegible] this error. The [illegible] blood & cause permanent scars. The active eruption lasts about three weeks & is followed by some anaesthesia of the skin.

similar in nature to those which may be present, but are not always so, upon the lips or angle of the nose. The patients are usually suffering from some febrile condition, *e.g.*, influenza, pneumonia, &c., but it may be so trivial as to escape observation. The vesicles are scarcely the size of a pin's head and are often arranged in rows or groups. They quickly rupture, forming abrasions which heal rapidly, leaving no opacity. In severe cases,

whooping cough,

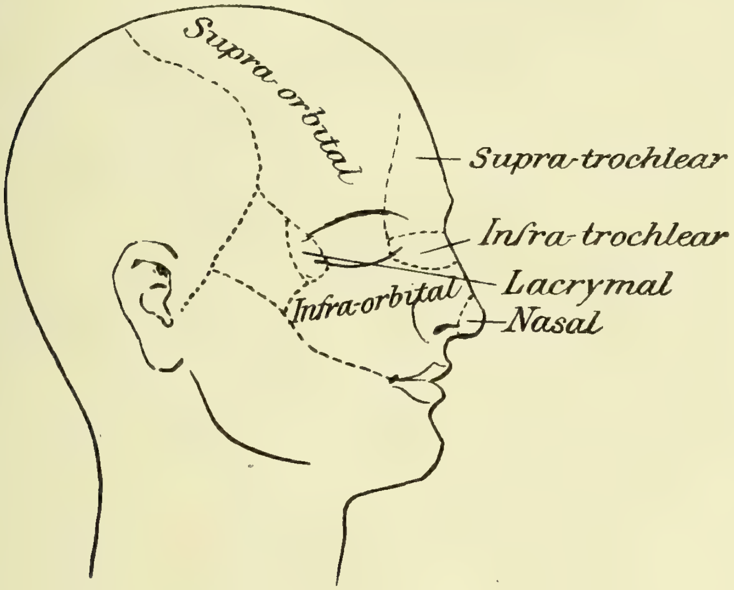


FIG. 132.—Distribution of the branches of the ophthalmic division of the fifth nerve on the face.

~~however,~~ ulcers are formed (*vide* p. 257). The acute stage is accompanied by great irritation, lacrymation, and blepharospasm. The ocular affection is usually unilateral and on the same side of the face as vesicles on the lips, &c. The cornea is generally not anæsthetic except at the spots attacked.

In herpes ophthalmicus one or more of the branches of the ophthalmic division of the fifth nerve (Fig. 132) is marked out by rows of vesicles or the scars left by them, exactly as in herpes zoster in other parts of the body.

Corneal vesicles are rare, but when they occur are exactly like those of the febrile form, and behave in the same manner. More commonly there is a diffuse deep infiltration of the cornea, associated with iridocyclitis (*q.v.*). The cornea is usually insensitive. This is tested by touching it with a wisp of cotton wool, and comparing with the opposite eye. The slightest touch is followed by reflex closure of the lids if the cornea is sensitive. The intraocular tension is not

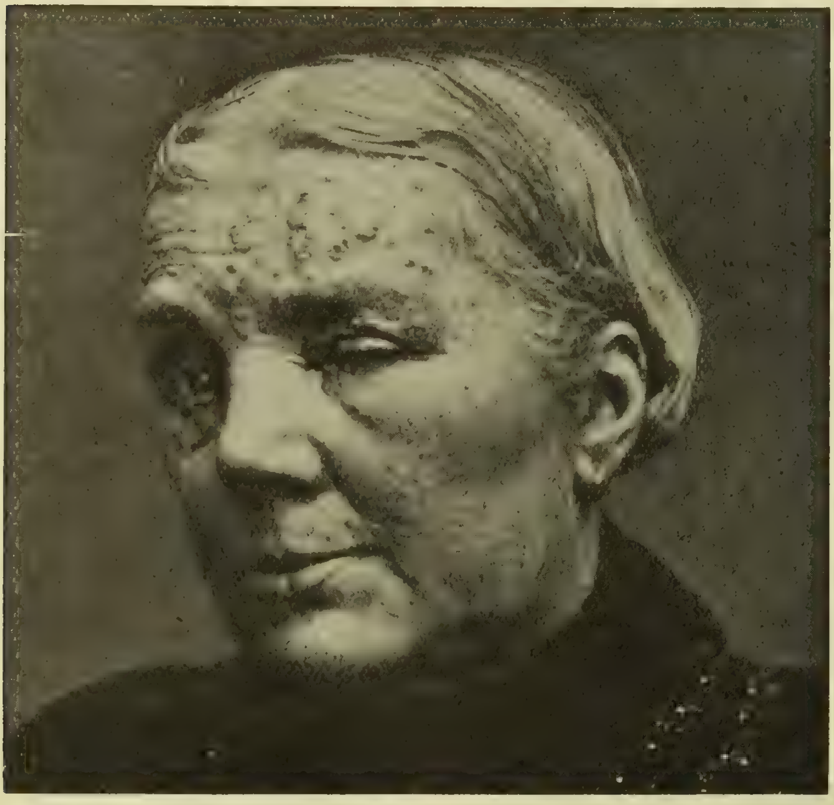


FIG. 133.—Herpes ophthalmicus.

q. infrequently somewhat diminished in the early stage. The disease is due to lesions in the Gasserian ganglion of the same type as those found in the posterior root ganglia in herpes zoster. ~~Patients often give the history of an attack of "erysipelas," but the typical distribution of the scars removes any difficulty in diagnosis.~~

Herpes corneæ may be mistaken for phlyctenular

(58)

¶1. Herpes ophthalmicus ~~may~~ occurs at any age, but generally in elderly people. Not infrequently there is a history of contact with patients suffering from chicken-pox, & evidence is accumulating that the relationship is more than a mere coincidence. This may account for the fact that herpes zoster is apt to occur in epidemics, ~~[illegible]~~ which are more common in the spring & autumn than at other times.

(59)

i.e., microscopic thromboses & haemorrhages similar to those found in the anterior cornual nuclei in anterior poliomyelitis. This disease shows many analogies on the motor side to herpes zoster. Probably both are ~~due to~~ caused by infection, the lesions being due either to bacterial invasion or more probably toxins.

persisting

/ They are then liable to be mistaken for herpetic ulcerations, from which they are distinguished by their [illegible] the [illegible] associated [illegible] when [illegible] have been altered, [illegible] ~~epithelium~~ of the respiratory vesicle, [illegible] the absence of [illegible] history of [illegible]

/ according to the type of ulcer, whether /

(60)

/, or papular.

¶ / In herpes ophthalmicus the skin may be treated with cocaine ointment (1%) & dusted with boracic powder. Cocaine [illegible] to relieve the pain. The [illegible] is generally [illegible]) [illegible]

patient should be kept indoors in bed during the acute stage

/ since it usually accompanies with influenza or catarrh of the respiratory tract /

/ if they may [illegible] faintly with fluorescein /

keratitis. The former occurs usually in adults, the latter in children. The clear vesicles differ in appearance from the grey infiltrations of phlyctenular keratitis. After the vesicles have burst, the shape and the total absence of vascularisation are distinguishing features.

Treatment.—The eyes should be protected with a bandage. When the vesicles have ruptured, atropin and warm compresses give most relief. It is sometimes necessary to use cocain when the pain is acute, though it has a bad effect upon the epithelium. Oily applications —ol. ricini—are sometimes grateful. Prolonged ulceration must be treated ~~as recommended~~ under dendritic ~~ulcer~~ (*vide* p. 257). The general health must be attended to; quinine, valerian, salicylic preparations, *e.g.*, salicylates, aspirin, &c., are useful.

An uncommon

Superficial Punctate Keratitis is ~~a rare~~ condition allied to herpes febrilis, but no vesicles are formed. It commences as an acute conjunctivitis. At this stage, or after it has passed off, rows of superficial grey dots are seen scattered over the cornea, least at the periphery. They remain unchanged for months, but gradually disappear. The disease affects one or both eyes in young people, ~~usually with some febrile affection.~~

groups or

Treatment as for herpes.

Interstitial Keratitis (*Syn.—Parenchymatous Keratitis*) is a deep keratitis usually affecting children between the ages of five and fifteen, the subjects of congenital syphilis. It is commoner in girls than boys.

After slight irritative symptoms, with some ciliary congestion, one or more hazy patches appear in the cornea, near the margin or towards the centre (Plate VII., Fig. 1). If they are near the margin they push forwards towards the centre; if at the centre, others appear and fuse, until finally the whole cornea looks lustreless and dull. Minute examination shows that the patches are in the deep layers and are made up of denser spots and fine streaks. In two to four weeks the whole cornea is hazy with a steamy surface, giving a general appearance like that of ground glass. Denser spots can always be seen in the general mist. In the severest cases the whole cornea becomes quite opaque, so that the iris is hidden; as a rule the iris can be seen dimly.

Meanwhile vascularisation has occurred. It is of the deep type (*vide* p. 106), consisting of radial bundles of brush-like vessels. The larger marginal plaques may be very vascular; as they are covered by a layer of hazy cornea their bright scarlet is toned down to a dull reddish pink ("salmon patches"). The separate vessels can only be seen by magnification. The small salmon patches are often crescentic; when larger they are sector-shaped. The opacity extends a little beyond the vessels, which seem to push the opacity in front of them. In the acme of the condition the vessels run in radial bundles almost, but seldom quite, to the centre of the cornea. There is often a moderate degree of superficial vascularisation, greater in some cases than in others, but never extending far over the cornea. The conjunctiva may be heaped up like an epaulette at the limbus, so that some slight resemblance to phlyctenular keratitis may be seen. Indeed, it is probable that these patients are both syphilitic and "strumous."

After the disease has reached its acme it commences to subside. The cornea clears from the margin towards the centre, which may long remain hazy, though it too finally clears, except in the worst cases. As the cloudiness disappears the vessels become obliterated, but though they cease to carry blood they remain permanently as fine opaque lines; they can be demonstrated only by magnification either with oblique illumination or more definitely by the direct method (*vide* p. 144). The characteristic radial course and distribution affords permanent proof of

(61)

L Vascularisation is probably brought about for the supply of nutritive substances which cannot reach the cornea by the normal process of diffusion.

L The cornea should be examined in the dark room by oblique illumination with a corneal loupe, when the vessels will be seen as grey lines on a black background. It should then be examined by the direct method with a + 20 D lens behind the mirror. The edge of the pupil is brought into focus, & then either the head is withdrawn slightly or plus ~~[illegible]~~ lenses are added, the head being kept still, until the cornea is in focus. The vessels will then be seen as black lines against a red background.

L (p. 106, Fig. 69)

PLATE VII.

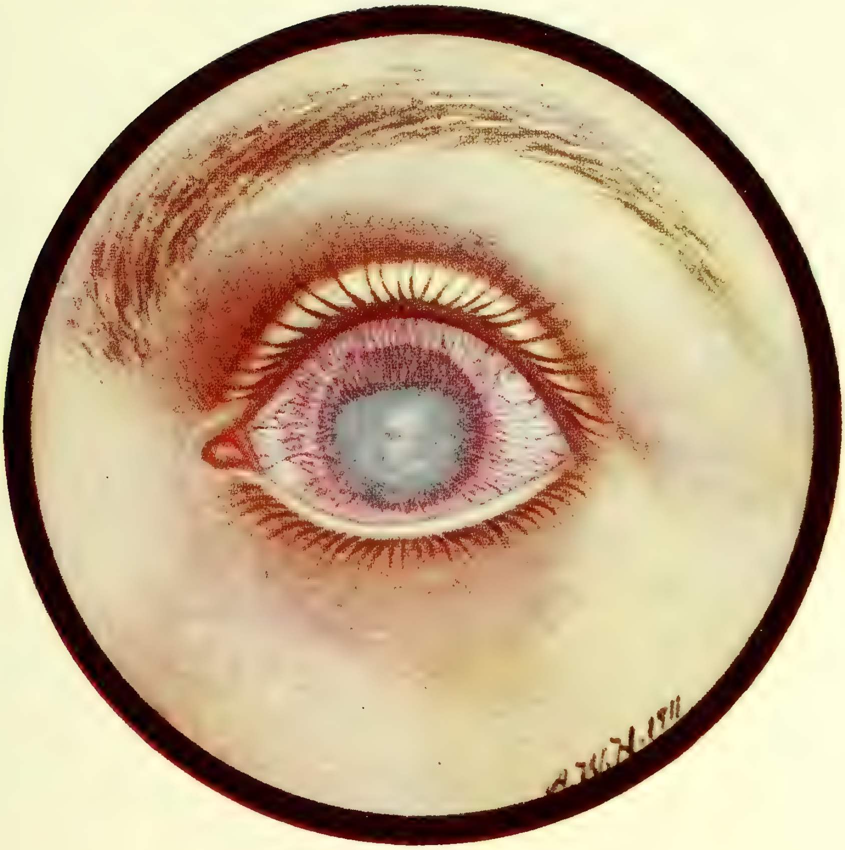


FIG. 1.

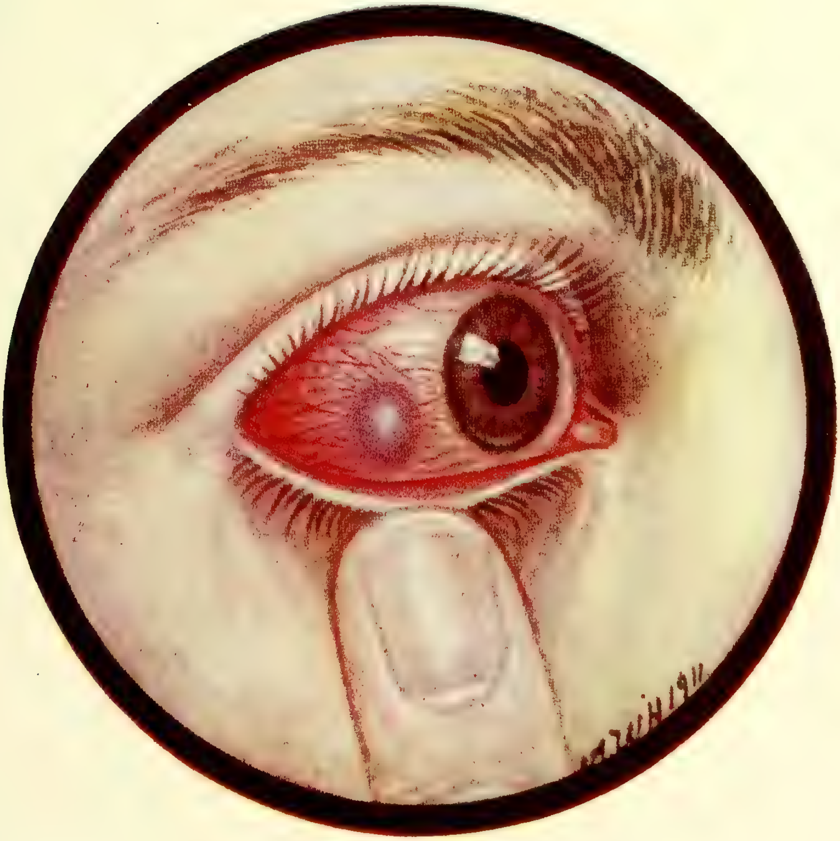


FIG. 2.

very rarely
~~Only [illegible] cases.~~

[illegible] intermittent headache [illegible] follows an injury to the head, much as it does [illegible]. [illegible] follows an attack of [illegible] [illegible] [illegible] [illegible] [illegible]. [illegible] [illegible] [illegible] [illegible] to the [illegible], [illegible] [illegible] [illegible] [illegible] [illegible].

The acute stage of ~~[illegible]~~ intermittent [illegible] lasts at least six weeks & may extend to ~~[illegible]~~ [illegible] months. The clearing [illegible] can be taken many weeks or months, [illegible] [illegible] [illegible]; it

uncommon, though probably not so rare as is generally [illegible]

Appended after eighteen months.

previous occurrence of interstitial keratitis, and is important evidence of congenital syphilis.

At the height of the disease vision may be reduced to finger-counting or hand movements, and there is much lacrymation and reflex blepharospasm. Very mild cases are met with in which the patches of cloudiness are thin, scarcely vascularised at all, and clear up quickly. In the marginal type the opacity may be limited to a sector.

The surface ~~never~~ becomes ulcerated. It is frequently stippled, steamy, and slightly uneven, and this condition may persist. In the worst cases the cornea may be enormously thickened and gelatinous in appearance. The impression given is that the cornea is very ectatic, and that the eye is in a hopeless condition; it will probably clear up well with useful vision. In no case must an eye be removed on account of interstitial keratitis.

Interstitial keratitis is almost invariably symmetrical, though an interval of three or more weeks usually intervenes before the onset in the second eye. Rarely the interval is several months or even years. Delayed interstitial keratitis, *i.e.*, in patients over thirty, occasionally occurs and is more liable to be unilateral; it is ~~also~~ often very severe. Interstitial keratitis in acquired syphilis is ~~rare, and~~ is also generally unilateral; several cases have been reported in which the primary lesion has been on the lids or face, and the keratitis has been limited to the same side.

Pathology.—The rare cases of interstitial keratitis which have been examined anatomically show that the infiltration of the cornea is almost entirely limited to the deeper layers lying immediately anterior to Descemet's membrane (Fig. 134).

It has been pointed out that corneal conditions which are secondary to conjunctivitis are superficial. Similarly deep keratitis is secondary to disease of the uveal tract.

Thus, in tubercle of the iris (*q.v.*) it is not uncommon in the late stages to meet with an interstitial keratitis fundamentally the same as in congenital syphilis. Further, anatomical investigation has shown that in the latter form the uveal tract is profoundly affected. Thus, it is the rule for a considerable degree of iritis to be present. Sometimes there is severe cyclitis, as shown by the presence of precipitates ("keratitis punctata," *vide* p. 301) on the back of the cornea. Not infrequently there is choroiditis. If the pupil of the unaffected eye is dilated and the periphery of the fundus carefully examined, patches of anterior choroiditis will not uncommonly be found. All these facts support the view that the disease is fundamentally a uveitis, and that the keratitis is secondary, *i.e.*, merely symptomatic. Clinically it masks the uveitis, which is thus liable to be overlooked, and hence the disease is called a keratitis. It is very important to realise the true pathology, since treatment must be

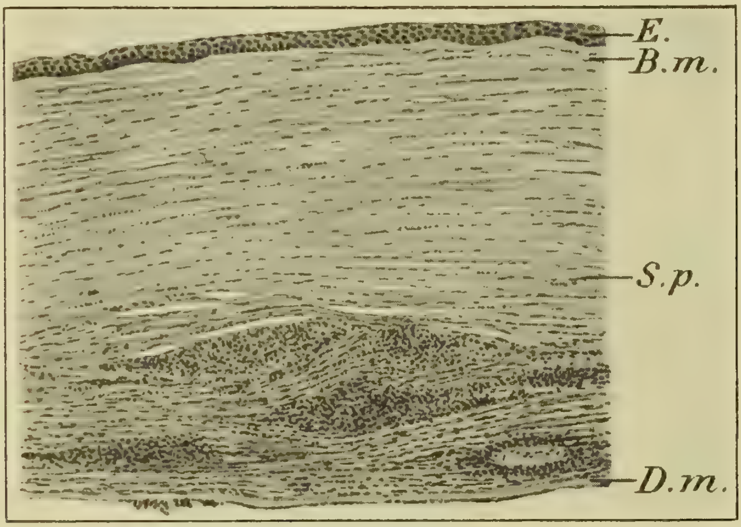


FIG. 134.—Section of interstitial keratitis, showing infiltration confined to the deeper layers of the substantia propria (× 60). *E*, epithelium ; *B.m.*, Bowman's membrane ; *S.p.*, substantia propria ; *D.m.*, Descemet's membrane with endothelium.

to be relied upon, but the other incisors and first molars are often deformed. The characteristic change in the central upper incisors appears to depend upon defective formation of the central lobe (Figs. 136, 139—140). Soon after eruption this lobe wears away, leaving a vertical notch at the centre of the cutting edge (Fig. 135). If the cause has acted so intensely as to prevent the development of the central lobe, there is, instead of a notch, a narrowing and thinning of the cutting edge as compared with the crown, and this according to its degree produces a resemblance to a screwdriver or peg (Figs. 137, 138). The teeth are too small in every dimension, so that the incisors are separated from one another by considerable spaces. In extreme cases all the incisors are peggy and much dwarfed. The changes are usually symmetrical, but Fig. 139 shows one tooth typically deformed and the other normal.

(3) Linear cicatrices, relics of former rhagades, are met with at the angles of the mouth. Cicatrices on the hard or soft palate or elsewhere in the mouth point to antecedent syphilitic ulcerations.

(4) Shotty, painless lymphatic glands are felt in the neck, especially in the posterior triangle.

(5) Hard periosteal nodules, best found upon the shins, and chronic synovitis of the joints, especially the knee joints, may be present.

Evidence of acquired syphilis may be sought in the parents.

Treatment.—It is usual to order antisyphilitic remedies, but it is doubtful if they have any influence over the course of the disease. Mercury inunctions, or powders or pills of mercury combined with chalk and ipecacuanha, or perchloride of mercury may be given. Iodide is best administered in children in the form of syrup of iodide of iron, and may be combined with syrup of phosphates h, partly because the cornea is non-vascular, ~~secondarily because the spirochaetes have become [illegible]~~

{ Salvarsan and its substitutes have proved of little value, probably owing to the fact that the spirochæte, if present in the cornea, is in a non-vascular medium.

(64)

radiant heat
{ Hot bathing should be used frequently in the acute stage. In stout adult cases with much congestion & [illegible] blepharospasm, especially if the pupils will not dilate with atropine, leeches applied to the temple do good. (see p. 397).

{ it should be well massaged into the eye

Hyoscine [illegible] (65)

as a tonic. Cod liver oil or maltine may be used when there is a tuberculous element about the condition, and in all cases general hygienic régime must be instituted.

Local treatment consists in guarding against the evil effect of the uveitis which is an invariable accompaniment of the disease. Atropin is ordered as a routine measure, with the double purpose of keeping the ciliary body and iris at rest and preventing the formation of posterior synechiæ. There is often great difficulty in getting the pupil to dilate, probably owing to defective penetration of the drug through the diseased and vascularised cornea. Smoked glasses are ordered.

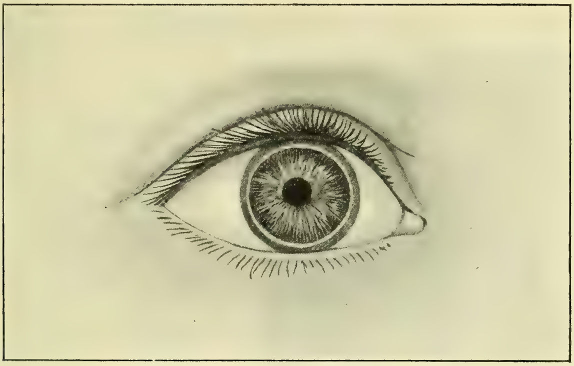


FIG. 141.—Arcus senilis.

In later stages the means used for clearing corneal cicatrices (*vide* p. 234), depending essentially upon improving the lymph flow through the cornea, are also indicated for the opacities of interstitial keratitis. Prolonged use of yellow oxide of mercury ointment, combined with atropin in the earlier stages, is commonly made.

Other forms of deep keratitis, *e.g.*, the central deep keratitis of adults, senile marginal deep keratitis, sclerosing keratitis (*vide* p. 280) occur. Like interstitial keratitis they are probably all secondary.

DEGENERATIVE CHANGES IN THE CORNEA.

Arcus senilis is a fatty degeneration of the cornea met with in old people (Fig. 141). It commences as a crescentic grey line concentric with the upper and lower margin of the cornea. The extremities of the crescents finally meet, and an opaque line, thicker above and below, is formed completely round the cornea. It is characterised by being separated from the margin by a narrow line of comparatively clear cornea. It is sharply defined on the peripheral side, fading off on the central. It is never more than about 1 mm. broad, and is of no importance, either from the point of view of vision or of the vitality of the cornea.

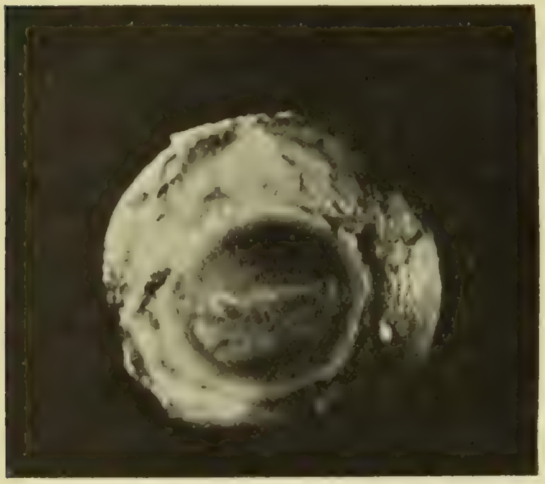


FIG. 142.—Band-shaped opacity of the cornea, from an eye with iridocyclitis.

Arcus juvenilis is exactly similar to arcus senilis, but is a rare condition found in children. Even arcus senilis may develop at a comparatively early age, but the juvenile condition is probably congenital. It is of no importance. The characteristic diagnostic feature of both these opacities is the presence of a line of clear cornea between them and the limbus. This is occasionally found in old sclerosing keratitis, but in this case the opacity is usually localised to some one part of the cornea and extends farther towards the centre.

Band-shaped Opacity (*Syn.—Transverse Calcareous Film, Zonular Opacity*).—This is a common condition in old, blind, shrunken eyes. It is due to defective nutrition

h, as in so many degenerative conditions, probably owing to the better nutrition [illegible] blood vessels.

(6b)

h, usually seizing out the young males of a family & coming up at about the age of 15 or 20 [illegible]. Opaque dots or fine lines appear just under the epithelium in the centre of the cornea & slowly increase in number but never invade the ring of cornea close to the margin. [illegible] The cause is unknown. There is little inflammation [illegible] & treatment is of little avail. Vision is gradually obscured.

and exposure. It lies entirely in the interpalpebral area, commencing at the inner and outer sides, and progressing until it forms a continuous band across the cornea (Fig. 142). Near the corneal loops, just inside the limbus, the cornea is generally relatively clear. The condition is due to hyaline degeneration of the superficial parts of the substantia propria, followed by the deposition of calcareous salts.

As a rare condition it is found in otherwise healthy eyes.

Treatment.—In the rare form last mentioned, improvement of vision may be obtained by scraping off the opacity, which is usually calcareous and quite superficial. In the common form the eye is blind, and nothing remains but to remove it if it is painful or unsightly.

Other Degenerative Changes are frequently met with in old leucomata, anterior staphylomata, and so on. They consist of hyaline degeneration, calcification, &c. Such scars are liable to a serious form of ulceration (*vide* p. 253).

Rare degenerative conditions are nodular and reticular opacities~~, &c. Little is known about them, but~~ they occur as a familial disease.

Ectatic Conditions.

It has already been stated that ectatic conditions of the cornea may result from inflammation, viz., keratectasia (*vide* p. 228), and anterior staphyloma (*vide* p. 230). Two forms of ectasia of non-inflammatory origin are known, viz., keratoconus and keratoglobus.

Anterior Staphyloma is a protuberant cicatrix arising from a prolapse of the iris; it may be partial or total (Fig. 111). It may follow a perforating wound, but is usually due to perforation of an ulcer, especially such as is caused by ophthalmia neonatorum. The primary protrusion occurs at the moment of prolapse. Cicatrisation follows, and in the case of small prolapse may lead to flattening of the scar. In other cases of small, and in all cases of large prolapse the contraction of the scar tissue is insufficient to bring this about, and the soft cicatrix yields to the normal intraocular pressure. Generally the prolapse of the iris leads to blocking of the angle of the anterior chamber, the intraocular tension rises, and the cicatrix yields still more, or if it was previously flat, secondary protrusion takes place.

Partial staphylomata are usually conical, rarely hemispherical; they usually extend to the margin on one side. Total staphylomata are usually hemispherical, rarely conical. There is invariably a rim of cornea around the pseudo-cornea, this rim being well nourished by the peripheral blood vessels and never necrosing through ulceration. The thickness of the staphyloma varies very greatly in different cases, and often in different parts of the same staphyloma. In the latter bands of cicatricial tissue develop, whilst the intermediate parts project; in this manner a racemose staphyloma is produced.

The pseudo-cornea is formed by organisation of the exudates on the surface of the prolapsed iris. It consists of fibrous tissue covered by epithelium, and lined by rarefied iris pigment epithelium. The epithelium on the anterior surface is often very thick and epidermoid; the fibrous tissue often undergoes degeneration. The anterior chamber is obliterated in total staphyloma, whilst the posterior chamber is enormously enlarged, and filled with yellow albuminous fluid.

The sight is always diminished, and in total staphyloma is reduced to perception of light or total blindness. The eye may project between the lids, so that a xerotic

Owing to the rise of intraocular tension the whole eyeball expands, especially in children, ~~[illegible]~~ when the walls are relatively plastic. If the lens has not been expelled when the ulcer perforated, as sometimes happens, it is flattened, the expansion of the ciliary ring causing ~~[illegible]~~ stretching of the suspensory ligament. The high intraocular pressure also causes cupping of the optic disc.

[Sometimes the whole series appears produce a condition which
is almost identical with the hesitation (cf. p. 279) of
infantile stammering, though due to a different cause.

condition is set up and atheromatous ulcers may form. Ectropion of the lids may occur mechanically. The tension is raised, either as the cause of the protrusion, or as a result of the blockage of the angle of the anterior chamber (Chap. XIV.). This may lead to pain. The staphyloma may be so thin that rupture occurs on the least injury, and may be several times repeated.

Treatment.—Total anterior staphyloma is best treated by excision of the eye, with or without the insertion of a glass globe in Tenon's capsule. Patients will often prefer to keep the eye if it is painless and not too disfiguring.

Various methods of ablation, in which the anterior part of the eye is removed and the contents scooped out, have been devised as an alternative for excision. They give a movable stump on which to set an artificial eye, but they are open to the objection that they are not entirely free from the danger of causing sympathetic ophthalmia (*q.v.*).

Treatment of partial staphyloma is directed to obtaining flattening of the cicatrix, preventing or relieving increased intraocular tension, and improving sight. The attempts which should be made at the early stage have already been described (*vide* p. 242). Iridectomy is sometimes advisable with a view to improving vision and preventing or curing glaucoma (*q.v.*). It cannot be performed at the site of the staphyloma, since there is no anterior chamber here, but must be done over the clearest part of the cornea.

Keratectasia differs from anterior staphyloma in that the iris takes no part in it. Its causation and prevention have already been discussed (*vide* p. 228). When it is fully developed treatment is useless.

Keratoconus (*Syn.—Conical Cornea*) is probably due to a congenital weakness of the cornea, though often it only manifests itself after puberty. The cornea is thin and weak near the centre, and gradually bulges forwards more and more ; the apex is always slightly below the centre. It is at first perfectly transparent, and vision is impaired through the protrusion and alteration in curvature. If advanced the conical shape is easily recognised in profile. In the less advanced cases diminution in the size of the corneal reflex over the centre is the chief guide. With the ophthalmoscope mirror at a distance of 1 metre a ring of shadow concentric with the margin is seen on the red reflex, altering its position on moving the mirror. It is due to a zone through which few rays pass into the observer's eye owing to the emergent rays on the central side being convergent whilst those on the peripheral side are divergent.

The patient becomes myopic, but the error of refraction cannot be satisfactorily corrected with glasses owing to the hyperbolic nature of the curvature. The condition is almost invariably bilateral, though frequently more advanced on one side than the other. It may be extremely slight and very slowly progressive, or the reverse. In the later stages the apex may become opaque, but ulceration, rupture, increase of tension and so on do not occur.

Treatment.—Various methods have been adopted to stop the process. Miotics are probably useless. The best treatment is cauterisation of the apex with the actual cautery. The cauterisation at the extreme apex must be deep, and perforation here has been advocated. The latter procedure is not without danger to the eye. Some operators remove a small wedge-shaped slice from the thickness of the cornea at the apex. It is more difficult to perform and does not give better results on the whole than the cautery. The scarring from cauterisation is much less than might be anticipated, but it may be advisable to do an optical iridectomy if vision is still very bad.

(69) L Sometimes it pulsates synchronously with the carotid pulse, & this may cause a subjective apparent pulsation of the objects looked at. The pulsation may be demonstrated with Schiötz' tonometer.

(70) L These changes are best seen when the reflex from a large flat disc painted with concentric black & white lines (Placido's disc or Keratoscope) is observed.

(71) L In the early stages every effort should be made to improve vision with glasses & the progress should be carefully watched.

L from the formation of a corneal fistula, anterior synechia, infection, &c

L Anterior sclerectomy (trephining) has been performed for conical cornea but without advantage.

Keratoglobus is the hemispherical protrusion of the whole cornea which is met with in infantile glaucoma (*q.v.*).

Symptomatic Conditions.

There are many pathological conditions of the cornea which are merely evidence of disease in other parts of the eye or of extension of disease. Some are often described as true diseases of the cornea, notably as forms of "keratitis." This involves a wrong principle and a misuse of terms which can only lead to confusion. Since it is of great importance to distinguish these conditions from primary affections of the cornea, both from the points of view of diagnosis and treatment, it will be well to review the more common here.

In **glaucoma** there is nearly always uniform diffuse bluish haze of the whole cornea. It is due to alterations in the refractive conditions of the corneal elements, brought about by the increased intraocular pressure, and not to any gross pathological change. If the condition persists the cornea becomes hazy throughout, and this haziness, unlike the former, does not immediately disappear when the intraocular tension is relieved. Here there is definite œdema, due to the impediment which prolonged tension causes to the diffusion of lymph. It manifests itself first in the epithelium, which becomes steamy and stippled. Sections show that this is due to accumulation of fluid in and between the cells, especially the basal cells (Fig. 143). Fluid also accumulates between the lamellæ and around the nerve fibres. If the œdema lasts for a very long period, as in eyes blinded with absolute glaucoma, the epithelium may be raised into vesicles or bullæ (*vesicular or bullous "keratitis"*). The evidence of prolonged tension makes it easy as a rule to distinguish this condition from herpetic vesicular keratitis; moreover the vesicles or bullæ have firmer epithelial walls and show less tendency to burst.

Nearly allied to bullous "keratitis" is the formation of epithelial threads, which adhere to the cornea by one end, whilst the other, which is often club-shaped, hangs down free. This is commonly called *filamentary* "*keratitis.*" It occurs in the same conditions, *i.e.*, usually associated with glaucoma, but it may be seen rarely without any apparent cause in cases of the herpetic type.

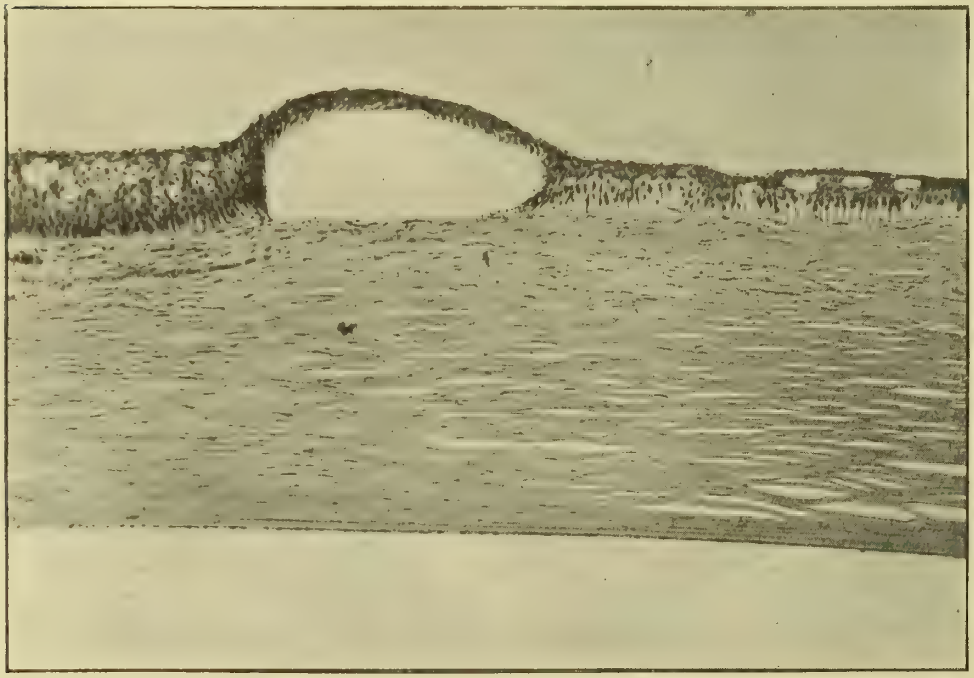


FIG. 143.—Œdema of the cornea and vesicular "keratitis," from a glaucomatous eye (× 60).

Keratic recipitates, usually badly termed "keratitis punctata" or "k.p." in England, are often deposited upon the back of the cornea in cyclitis and iridocyclitis. The greatest care must be taken not to overlook them, since they may be almost the only objective sign of serious disease. They may be on the back of a clear cornea or the deeper layers may be infiltrated as a result of the

iridocyclitis; thus, they are not uncommon in interstitial keratitis. Their appearance and nature will be described in discussing their cause (*vide* p. 300).

Opacities of the cornea are often secondary or symptomatic. Such are the grey or white, usually tongue-shaped marginal opacities which follow scleritis. Owing to their resemblance to the sclerotic they are called *sclerosing* "*keratitis*" (*vide* p. 280).

Congenital opacities of various kinds are sometimes met with. Many are not truly congenital, but are due to injury received at birth.

Striate opacity occurs in various forms. The commonest form is that seen after operations upon the globe in which a peripheral section has been made, as in cataract extraction. Here, when the section is above, delicate grey lines run down vertically from the wound and may pass completely across the cornea (Fig. 144). They can be seen clearly only by magnification. They disappear spontaneously as the wound heals. They are due to slight folding of the cornea, whereby Descemet's membrane and the adjacent lamellæ become wrinkled. Radial striæ are seen around wounds or ulcers; they are partly referable to the same cause, partly to distension of the interlamellar spaces by œdema. The fine hatching which is seen around ulcers and sometimes after tight bandaging are to be referred to similar causes.

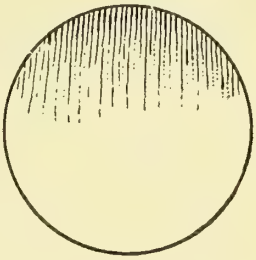


FIG. 144. — Striate opacity of the cornea, following section of the cornea above for extraction of cataract.

Opacities of the cornea may be due to improper treatment. One of the commonest is due to *deposits of lead salts* upon an abrasion or ulcer. An insoluble, densely opaque white film is precipitated and adheres very firmly. The spot is sharply defined and looks like white paint.

Probably the deposit is always thrown off eventually, but a very long time may elapse. An attempt should be made to scrape it off, but it is wisest never to use lead lotions at all in the treatment of any affections of the eye. They can always be replaced by equally efficient substitutes.

Pigmentation of the cornea may also occur from improper treatment. Prolonged use of silver nitrate as a paint or in the form of drops is followed by dark brown staining of the conjunctiva and slight staining of the cornea. The condition is called *argyrosis*, and in the conjunctiva is found to be due to impregnation of the elastic fibres with metallic silver; in the cornea Descemet's membrane is stained. It is permanent; hence silver solutions, including protargol, argyrol, &c., should never be ordered as drops or for use at home, at any rate without stringent injunctions.

Blood in the cornea is rare. It may occur as a bright red spot quite superficially at the margin or as a greenish or rusty stain over the whole surface. In the latter case it is derived from blood in the anterior chamber, associated with high tension—a relatively infrequent combination. The stain is due to minute rod-shaped granules of derivatives of hæmaglobin in the lamellæ. It clears very slowly from the margin, and in this stage resembles extraordinarily the appearance of the lens when it is dislocated into the anterior chamber.

Tumours of the cornea, so-called, are probably always secondary extensions, most commonly from the conjunctiva, the limbus being a favourite situation for these growths (*vide* p. 218).

L (v. p. 218)

CHAPTER XII.

DISEASES OF THE SCLEROTIC.

Redness of the white of the eye is caused by a variety of conditions. The commonest is conjunctivitis; the next common some inflammation of the anterior part of the uveal tract, viz., the iris and ciliary body. Some of the distinctive characteristics of the redness in conjunctival and ciliary inflammation have already been pointed out (*vide* p. 96). Redness of the white of the eye may also be caused by inflammation of the sclerotic, and it is a frequent error amongst beginners to ascribe the other forms to this disease. It must therefore be borne in mind that episcleritis and scleritis are relatively uncommon.

Inflammation of the Sclerotic.

Two forms of inflammation of the sclerotic are described, superficial or episcleritis, and deep or scleritis. They might equally well be considered mild and severe forms of the same disease, but the distinction is convenient clinically since they usually differ in the course they take.

Episcleritis is an inflammatory affection of the deep subconjunctival connective tissues, including the superficial scleral lamellæ. A circumscribed nodule, which may be as large as a lentil, appears usually two or three millimetres from the limbus (Plate VII., Fig. 2). It is hard, immovable, and very tender, the conjunctiva moving freely over it. It is traversed by the deeper episcleral vessels, and therefore looks violet, not bright red. It is extremely chronic, never ulcerates, and may be entirely absorbed, but more frequently leaves a slate-coloured scar behind, to which the conjunctiva is adherent. The cornea and uveal tract rarely participate in the inflammation.

There may be little or no pain, but usually there is a feeling of discomfort and tenderness on pressure, and severe "neuralgia" is often complained of. The nodule becomes gradually absorbed in the course of days, or, more frequently, weeks, but during the process of absorption, or soon after, fresh nodules of the same type arise. In this manner the disease may drag on for months. Both eyes are frequently affected. In the worst cases the disease extends into the deeper parts of the sclerotic, and thus passes almost imperceptibly into scleritis.

Anatomically dense lymphocytic infiltration of the subconjunctival and episcleral tissues is found.

Rheumatism and gout are commonly indicted as the chief causes of episcleritis. A history of acute rheumatism is rarely obtained; more commonly there has been well marked "muscular rheumatism." Tuberculous or syphilitic patients seem predisposed, and almost invariably there is some cause of general debility. It is commonest in elderly people (cf. Scleritis), and in women.

Treatment.—General treatment is of more avail than local. Even in cases in which no history of rheumatism can be elicited, salicylic preparations—salicylates, salicin, aspirin—seem to do good, and should be tried. If they fail resort should be had to iodides.

The most useful local treatment is massage by the finger applied to the upper lid. A simple boric ointment may be used or a weak yellow oxide of mercury ointment, but strong stimulants can rarely be borne. In the more severe cases warm compresses, ~~atropin~~, and leeches to the temple should be employed. In the worst cases the constant current, scarification or superficial cauterisation are indicated. Every effort must be made h, which is ~~both are~~ to be ascribed to septic absorption (v. p. 302)

sionin/

to build up the constitution, and success often depends upon these measures.

Scleritis is rarer than episcleritis. There are usually nodules, or a single nodule, but the area affected is much less circumscribed. The swelling is at first dark red or bluish, later it becomes pale violet and semitransparent, like porcelain. It may extend entirely round the cornea, forming a very serious condition known as *annular scleritis.* Scleritis differs from episcleritis in that the cornea and uveal tract are involved, some iritis, but more cyclitis and anterior choroiditis being present. There is no ulceration, but much absorption, so that the sclerotic is thinned, a dark purple cicatrix being formed, which is often too weak to withstand the intraocular pressure, so that ectasia follows (*ciliary staphyloma*). In many cases of diffuse deep scleritis hard whitish nodules develop in the inflamed zone. They are the size of a pin's head and lie beneath the conjunctiva, all at about the same distance from the corneal margin : they disappear without disintegrating.

Anatomically scleritis is the same as episcleritis, but extends deeper ; there is dense lymphocytic infiltration of the sclera, the lamellæ being separated by cords of cells.

Both eyes are usually affected. Young adults are the most common subjects (cf. Episcleritis), and women more often than men. The causes are obscure, but of the same type as in episcleritis.

Scleritis is most serious on account of its sequelæ and complications. Uveitis of some kind is probably an invariable accompaniment. It is uncertain whether it may be a result or a cause of the scleritis ; most probably it is neither, but both are due to a common cause. This cause is probably the absorption of toxins from some septic focus. It is often difficult or impossible to find the focus, but special attention should be directed to the nasal sinuses and generative organs, the latter especially in women. In other cases the alimentary canal is probably at fault, and many of the drugs which have been found beneficial probably act chiefly by disinfecting the intestinal tract. In some cases the disease is undoubtedly tuberculous and in others syphilitic. Ciliary staphyloma leads to distortion of the globe, and vision is impaired by it and by the many deleterious effects of the uveitis. Secondary glaucoma ~~usually~~ follows.

Apart from these complications scleritis nearly always extends to the cornea, causing *sclerosing keratitis* (Fig. 145). An opacity develops at the margin of the cornea near the scleritic nodule. It is approximately triangular or tongue-shaped, the rounded apex being towards the centre of the cornea. Similar opacities may develop farther from the margin and even at the centre. The opacities are grey or greyish yellow, becoming denser until they exactly resemble the sclerotic—hence the name. There is little or no vascularisation, and ulceration never occurs. Some clearing from the centre towards the periphery, as well as near the marginal corneal loops, occurs, but the densest parts usually persist as bluish clouds. The whole margin of the cornea may become opaque like the sclerotic, but the pupillary area almost invariably escapes.

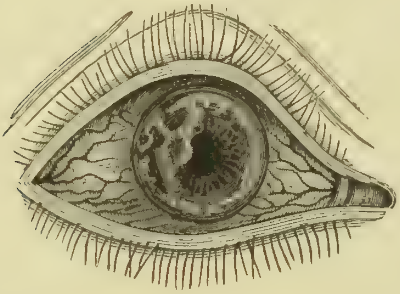


FIG. 145.—Sclerosing keratitis. (Nettleship.)

Treatment is the same as for episcleritis. When tubercle is suspected injections of tuberculin ~~should~~ be employed. Dionin and subconjunctival injections of saline, &c., have been recommended.

Ulceration of the sclerotic is always secondary, either from without or from within. Extension from the

72

Stock has produced scleritis, occurring there with ~~tuber~~ lesions in the uveal tract by the intravenous injection of tubercle bacilli in rabbits. There is little doubt that tubercle plays a bigger part in ~~tubercle~~ of diseases of these structures in man than has hitherto been recognised.

73

They are indeed due to changes in the substantia propria, which is embryologically a specially differentiated part of the sclerotic.

Uveal complications must be treated with atropin, &c (See Chap. XII).

74

¶ Gumma of the Sclerotic is uncommon. It may be indistinguishable in appearance from scleritis, or it may take the form of nodules of various sizes, situated near the limbus, ~~or~~ extending backwards to the equator, or even giving rise to an annular scleritis. Gumma may ~~spread~~ spread to the interior of the eye or a gumma of the ciliary body may spread outwards & involve the sclerotic. Unless active antisyphilitic treatment is adopted early & carried out thoroughly the eye is very likely to be lost from uveal complications, ciliary staphyloma, or phthisis bulbi.

The diagnosis depends upon the history, co-existing signs of syphilis, & the application of the Wassermann test.

¶ Tubercle of the Sclerotic may take the form of a scleritis, may be an extension from the conjunctiva, iris, ~~or~~ ciliary body or choroid, or may be primary, forming a localised nodule which caseates & ulcerates. It should be excised or scraped & the ~~[illegible]~~ tissue examined for tubercle bacilli.

Continued next page

(p. 280 Cont'd) Annular Scleritis, as already mentioned, may be a form of ordinary scleritis or of gummatous scleritis. A severe type is sometimes known as 'brawny scleritis' & is characterised by brownish-red, gelatinous-looking swelling surrounding the cornea & spreading back towards the equator. It generally occurs in old people & is particularly rare, for it is ~~very chronic~~ little amenable to treatment. Some cases, but not all, give a positive Wassermann reaction.

Blue Sclerotics – The sclerotic is bluish in babies, but a marked or pronounced blue colouration is sometimes seen in several members of the same family, is an hereditary condition, & persists throughout life – A curious & hitherto unexplained feature of these cases is that ~~they~~ the ~~are often associated with~~ patients often suffer from fragilitas ossium.

conjunctiva is almost always due to tuberculous ulceration, rarely syphilitic. Extension from within is almost always from the iris or ciliary body and is usually tuberculous in the case of the iris, syphilitic in that of the ciliary body. Ulceration of malignant growths which have perforated the sclerotic also occurs—sarcoma of the iris or ciliary body, glioma of the retina. All these conditions are rare.

CHAPTER XIII.

DISEASES OF THE IRIS AND CILIARY BODY.

The uncouth term *uveitis* has the merit of emphasising an important fact, viz., the close relationship which exists between the anatomically distinct parts of the uveal tract. It draws attention to the frequency with which inflammatory processes involve the tract as a whole, and are not strictly limited to a single part. This feature is particularly well exemplified in inflammation of the iris and ciliary body. Probably iritis never occurs without some cyclitis, nor, *a fortiori*, cyclitis without some iritis. The disease is called iritis or cyclitis according as the iris or ciliary body appears clinically to be the more affected. The same disposition is also seen with regard to the choroid, though in less degree. General uveitis is ~~most~~ common in the more chronic types of inflammation, but it is probable that the ciliary body is often involved in many cases which we are accustomed to regard as pure choroiditis.

For convenience of description it is best to consider diseases of the various parts of the uveal tract separately, but the anatomical, physiological, and pathological continuity of the parts can be scarcely too forcibly insisted upon.

Inflammation of the Iris and Ciliary Body.

Iritis.—In order that iritis and the special dangers which attend it may be thoroughly understood, it is necessary to remember the anatomical arrangements of

the iris and the pathological changes which occur in it. The iris is practically a diaphragm of blood vessels and unstriped muscle fibres held together by a very loose, spongy stroma. In its perpetual movements the pupillary margin slides to and fro upon the lens capsule. The more the pupil is constricted the more of the posterior surface of the iris is in contact with the lens capsule; when fully dilated the iris probably does not touch the lens at all.

Inflammation of the iris is fundamentally the same process as occurs in other connective tissues: it consists in dilatation of the blood vessels, impairment of the capillary walls, exudation of a highly albuminous lymph into the tissue spaces, and leuco- or lympho-cytosis. Owing to the extreme vascularity of the iris and the peculiar distribution of the vessels, and to the looseness of the stroma, these generic features of inflammation produce special results. Thus, simple hyperæmia tends to cause the pupil to contract mechanically, on account of the radial disposition of the vessels. This is to some extent physiological, but is greatly increased under pathological conditions. The extreme vascularity and the looseness of the tissues causes an unusually large amount of exudation on the one hand and of swelling on the other. Owing to the greater albuminous content of the fluid its viscosity is increased so that it escapes into the anterior chamber and out of the anterior chamber by way of the filtration angle (*vide* p. 23) with greater difficulty. The iris, from being a partially wrung-out flat sponge becomes a sponge full of sticky fluid. Hence its freedom of movement is greatly impaired, and the normal reactions become very sluggish or completely abolished. The fluid, too, contains deleterious substances which act as irritants; the nerve endings are stimulated so that the muscle fibres contract. In any case in which the sphincter and dilatator fibres are equally and uniformly stimulated the sphincter overcomes the dilatator, so that constriction of the pupil follows.

It is easy now to understand the chief signs of iritis. The pupil is constricted, partly owing to hyperæmia, partly to irritation; the edge of the pupil is markedly irregular. The reactions of the pupil are sluggish, partly owing to the same causes which induce constriction, partly to what may be termed water-logging. The latter condition causes an alteration in the appearance of the iris. The delicate iris pattern, instead of being clear and sharply defined, becomes blurred and indistinct ("muddy" iris). The colour undergoes considerable change, varying according to the condition of normal pigmentation. In fair people with little pigmentation, the blue iris becomes bluish or yellowish green; brown irides show less difference, but become greyish or yellowish brown. In any case comparison of the colour of the two irides will usually reveal some slight difference, for iritis is generally unilateral during the acute attack.

As a result of the change in colour and blurring of the iris pattern, the hyperæmia of the iris itself is not very obvious, but it manifests itself in circumcorneal ciliary congestion (*vide* p. 96). This is most marked if the ciliary body is seriously involved, but the conjunctival vessels are also frequently moderately engorged, so that care is necessary in distinguishing the condition from conjunctivitis. The secondary nature of the conjunctival congestion is shown by the relatively slight discharge: what discharge there is is chiefly lacrymal, never mucopurulent in the absence of actual conjunctivitis as a complication.

The iris is richly supplied with sensory nerves from the ophthalmic division of the fifth nerve. It is not surprising, therefore, that pain is a prominent symptom

of acute iritis. It is not confined to the eye, though severe neuralgic pain is felt here, but is also referred to other branches of the first division of the fifth nerve, especially to the brow and parts supplied by the supraorbital and trochlear branches, but also to the cheeks and malar bone, and sometimes to the nose and teeth. It is worst at night.

The albuminous exudates escape slowly into the anterior chamber and mix with the normal aqueous. If the ciliary body is much involved the aqueous itself is abnormally albuminous. The aqueous often contains leucocytes and minute flakes of coagulated proteid, seldom fibrinous networks except in severe cases. It therefore becomes hazy, further interfering with a clear view of the iris and easily mistaken for haziness of the cornea, which is usually not involved. In very intense cases, especially of traumatic iritis with septic infection, large numbers of polymorphonuclear leucocytes are poured out; these sink to the bottom of the anterior chamber and form an hypopyon. Hypopyon is rare in simple iritis without perforation of the globe. Hyphæma, or blood in the anterior chamber, may also occur, but is rare in simple iritis.

The abnormal condition of the aqueous impairs the nutrition of the endothelium which covers the back of the cornea. The cells become sticky and may desquamate in places. The exudates tend to stick to the more affected spots, forming *keratic precipitates* (" keratitis punctata "). These are seldom present in simple iritis, but form a prominent feature of cyclitis, varying roughly with the amount of cyclitis present.

The more albuminous the aqueous the more viscous it becomes. This viscous fluid filters out of the anterior chamber by the filtration angle with difficulty. Hence there is a tendency for the fluid to be retained, so that the intraocular tension rises. The rise is minimal and of no serious import in cases of simple iritis—in fact, it is scarcely appreciable by clinical methods. If, however, the ciliary body is much involved the albuminous constituents of the aqueous are very markedly increased, and rise of tension may be so great as to endanger the sight, requiring special attention.

The exudates which are poured out by the iris and ciliary body are naturally most concentrated in their immediate neighbourhood. They cover the surface of the iris as a thin film and spread into, and often completely over, the pupillary area. In this manner the pupil may become "blocked" with exudates, a condition which very seriously impairs the sight of the eye. Moreover, the exudates tend to stick the iris down to the lens capsule, so that it becomes immovably fixed.

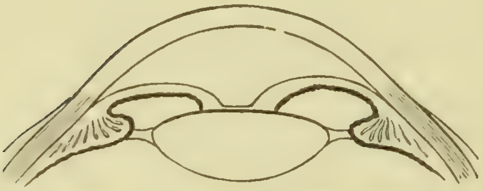


FIG. 146.—Diagram of seclusion and occlusion of the pupil, with bowing forwards of the iris ("iris bombé"). (Nettleship.)

If the patient is seen in the early stages and atropin is instilled the pupil dilates, though not so readily as a normal pupil, on account of the water-logging of the iris. By continuous treatment the iris may be freed from the lens capsule and the pupil becomes completely dilated and circular.

The exudates, however, show a great tendency to become quickly organised. This is particularly seen in most cases of iritis, less frequently in cyclitis; when it is a very marked feature of the case the inflammation is often described as *plastic*. If the exudates which bind the iris to the lens capsule have not been already broken down they become converted into fibrous bands which atropin is wholly unable to rupture. Such firm adhesions of the pupillary margin to the lens capsule are called *posterior synechiæ* (συνέχειν, to hold together). When they are

[illegible] publication [illegible]
[illegible] the preservation of the
plants [illegible].

present a mydriatic causes only the intervening portions of the circle of the pupil to dilate and the pupil assumes a festooned appearance (Plate VII., Fig. 2; Fig. 150). Even in the absence of a mydriatic minute inspection will generally show irregularities of the pupillary margin due to the synechiæ. Such an irregular pupil is a sign of present or past iritis. For diagnostic purposes homatropin should be instilled and the result confirmed by the appearance of the dilated pupil. Owing to the contraction of organising exudates upon the surface of the iris the retinal pigment epithelium may be pulled outwards over the pupillary margin. Patches of pigment are then seen in this situation (ectropion of the uveal pigment).

In very severe cases of plastic iritis, or after recurrent attacks, the whole circle of the pupillary margin may become tied down to the lens capsule. The condition is called *annular* or *ring synechia* or *seclusio pupillæ* (Figs. 146, 149); it is one of great danger to the eye (*vide* p. 308). In similar cases, especially if the case has been neglected and the pupil not well dilated by atropin at an early stage, the exudates in the pupillary area may also organise. A film of opaque fibrous tissue then fills the pupil; this condition is called blocked pupil, or *occlusio pupillæ* (Figs. 146, 149). If there had been much cyclitis the posterior chamber (Fig. 1) also becomes filled with exudates which may organise. They then tie down the whole of the back of the iris to the lens capsule; this condition is called *total posterior synechia* (Fig. 147). It leads to retraction of the peripheral part of the iris, so that the anterior chamber becomes abnormally deep at the periphery, sometimes much deeper than in the centre.

Iritis is most frequently mistaken either for conjunctivitis or for acute glaucoma. The points which distinguish it from conjunctivitis will be gathered from what has already been described. The error of mistaking iritis for glaucoma is the most serious which can be made, more particularly because the treatment of the two conditions is diametrically opposed. Dilatation of the pupil with atropin, which is urgently necessary in iritis, is the worst possible treatment of glaucoma (*q.v.*). At the cost of some repetition, the distinguishing features will be given here.

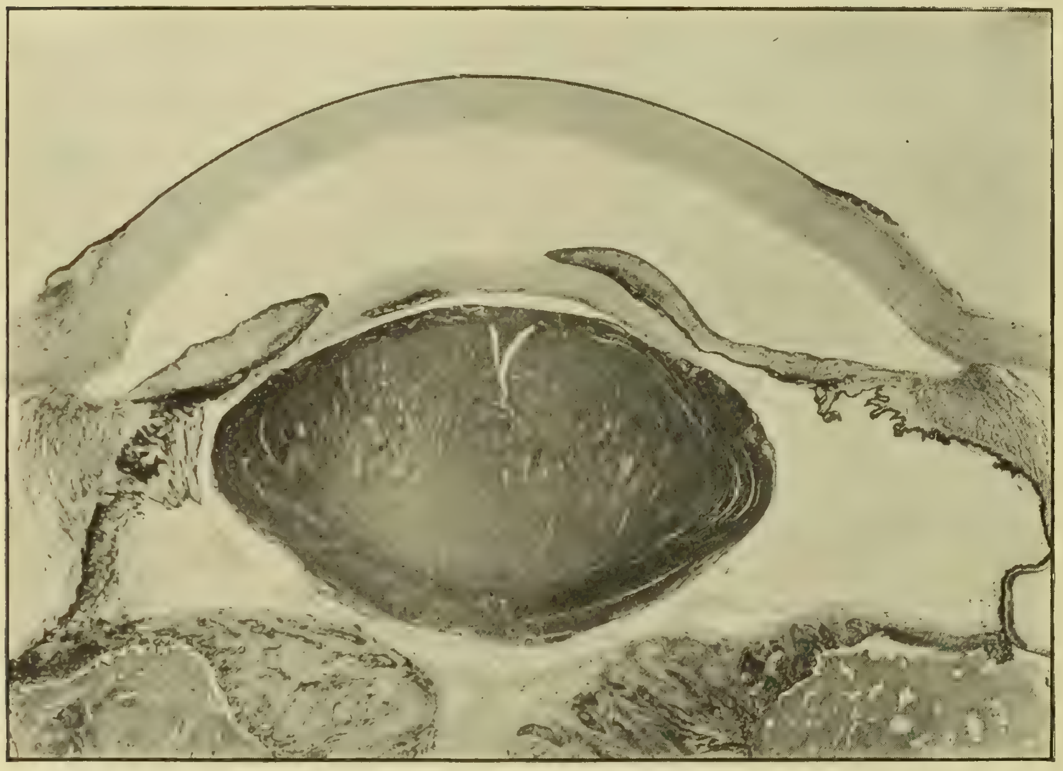


FIG. 147.—Total posterior synechia (× 7), from a case of plastic iridocyclitis commencing to cause phthisis bulbi. The iris is completely adherent to the lens capsule, and the periphery is retracted. There is a delicate inflammatory pupillary membrane (occlusio pupillæ). There is also an anterior capsular cataract, due to the inflammation ; it contains calcareous deposits, as shown by the patch of dark staining. The ciliary body is degenerated and detached from the sclerotic at the posterior part. The retina is completely detached and folded behind the lens.

(1) In iritis the pupil is smaller than normal and irregular ; in glaucoma it is larger and oval, usually with the long axis vertical.

(2) In iritis the intraocular tension is scarcely appreciably

raised unless much cyclitis is present; in glaucoma it is always appreciably raised, and is often very high.

These are the two chief objective signs. Cases occasionally arise which are doubtful even to the most experienced. A useful and harmless procedure which will almost invariably settle the question is the following: A drop of 2 per cent. homatropin (*not* atropin) solution is instilled. As the pupil dilates, in iritis the irregularities are emphasised and synechiæ are almost always revealed; the tension is not appreciably affected by the mydriatic; in glaucoma the pupil probably dilates slowly but quite evenly, retaining its roundness; the tension is appreciably increased by the mydriatic. As soon as glaucoma is definitely diagnosed by this test eserin (1 per cent.) must be *immediately* instilled and repeated at intervals (*vide* p. 326). Atropin is never to be used for diagnostic purposes since eserin is incapable of counteracting its mydriatic effect, and if the case is found to be one of glaucoma immediate iridectomy would be imperative.

(3) The subjective symptoms differ in the two diseases. Vision is usually more impaired in glaucoma than in iritis. In acute glaucoma the onset of the pain is sudden, and it is so severe that it is frequently accompanied by vomiting.

It will be advisable again to enumerate the chief symptoms and signs of iritis. The subjective symptoms are: pain, of a neuralgic character, referred not only to the eye but also to the supra-orbital region; dimness of vision, due to cloudiness of the aqueous, exudates in the pupillary area, &c. The objective signs are: constriction and irregularity of the pupil, unless a mydriatic has already been instilled, in which case the irregularity is emphasised by the presence of the posterior synechiæ. If the mydriatic is instilled early these synechiæ may break down so that the pupil again becomes quite round; in such cases spots of lymph or pigment upon the anterior capsule of the lens often leave permanent marks of old synechiæ, and form most valuable evidence of previous iritis (Fig. 148). It has already been pointed out (p. 5) that the posterior layer of the retinal pigment epithelium on the back of the iris is less firmly attached to the iris than the anterior. When a synechia breaks down some of the posterior layer often tears away and remains attached to the lens capsule; these pigmented spots never disappear entirely. Discoloration or muddiness of the iris, whereby the iris pattern is masked: hyperæmia, manifesting itself chiefly as circumcorneal ciliary congestion; exudations, manifesting themselves either as more or less cloudiness of the aqueous or as solid deposits in the pupillary area and upon the iris: these are conspicuous signs of inflammation of the iris.

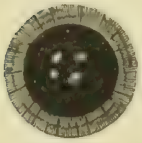


FIG. 148.—Spots of pigment on the lens capsule, left by posterior synechiæ which have broken down. (Nettleship.)

The course of iritis varies with its intensity. Even the slighter acute cases take three or more weeks before inflammation entirely subsides. The best sign is the prompt action of atropin, for in the worst cases it has little or no effect. Improvement is shown by good dilatation, diminution of injection and pain. In the chronic cases the ciliary body is almost always more seriously involved; the condition is one of irido-cyclitis. The inflammatory signs are less, but diminution of vision is progressive, and the disease not infrequently lasts for years.

One of the most characteristic features of iritis and cyclitis is the great tendency to relapse. It depends, not upon the synechiæ, as was once taught, but upon the constitutional cause of the disease. Each fresh attack runs a similar, though usually less severe, course, often leaving fresh traces and increased impairment of vision.

Complete resolution may occur in slight cases treated early and suitably. The exudates become absorbed, the synechiæ break down, leaving only such slight traces that vision may be perfect. Comparatively slight cases may, however, leave very serious results if they are improperly treated, and in severe cases these are the rule. Most of the evil results are attributable to neglect of or impossibility of early dilatation of the pupil, which causes permanence of the posterior synechiæ. If these are few, no special injury or impairment of sight follows, but future attacks are more likely to result in an increased number or in ring synechia.

Ring synechia, or seclusio pupillæ, is one of the worst sequels of the disease, since, if unrelieved, it inevitably leads to secondary glaucoma and destruction of sight. Owing to the complete shutting off of the pupil the aqueous which is secreted by the ciliary body (*vide* p. 21) is unable to pass forwards into the anterior chamber, the iris being a non-permeable membrane. It therefore collects behind the iris, which becomes bowed forwards like a sail, a condition which is called *iris bombé* (Fig. 149). Regarded from in front, the anterior chamber is seen to be funnel-shaped, deepest in the centre and shallowest at the periphery. The filtration angle is obliterated by the adhesion of the iris to the cornea and sclera at the periphery (peripheral anterior synechia). Hence the fluid is retained within the eye and the intraocular tension rises (*vide* p. 308).

Organisation of the exudates in the pupillary area leads to the formation of an inflammatory pupillary membrane or occlusio pupillæ. This interferes directly with the transmission of light rays and is often associated with ring synechia, with or without total posterior synechia (*vide* p. 287). In such cases there is generally plastic cyclitis and the eye is irretrievably affected.

Repeated attacks of iritis lead to atrophy of the iris, which becomes dirty grey, like felt or blotting paper. Red streaks often mark the site of permanently dilated vessels, usually of new formation and therefore not necessarily radial in direction. The pupillary margin is thin and frayed: the reactions are diminished.

Varieties of Iritis.—The varieties of iritis are usually divided into primary and secondary, the latter being those which are due to extension of inflammation from some other part of the eye, usually the cornea. The primary iritides are due to some general dyscrasia, though it is not always possible to determine its exact nature (so-called idiopathic iritis). The most undoubted cause is certainly syphilis; other causes are gonorrhœa, tubercle,

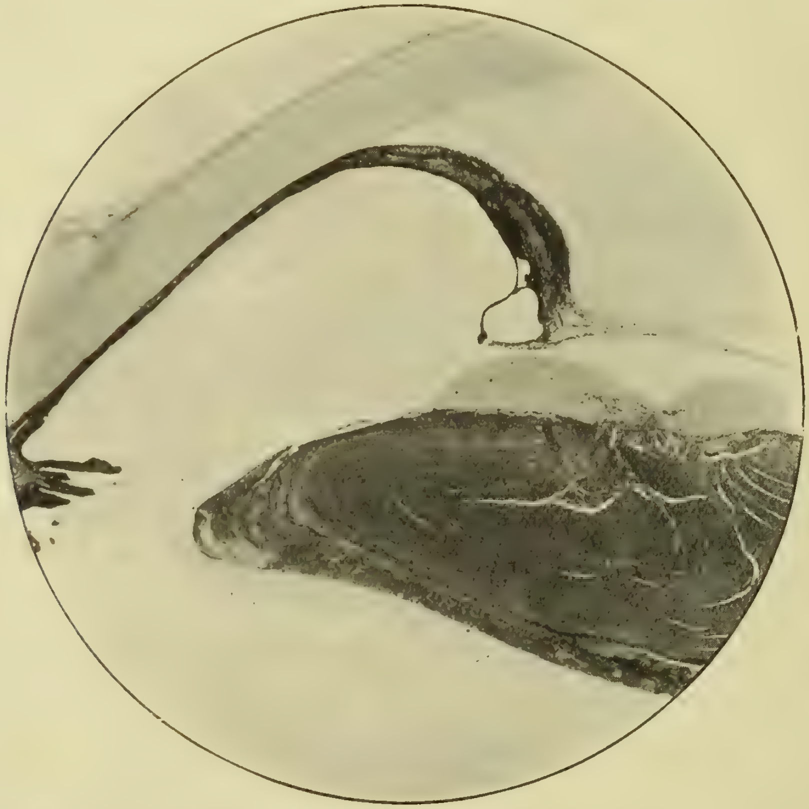


FIG. 149.—Iris bombé, with very broad peripheral anterior synechia, annular posterior synechia (seclusio pupillæ), and inflammatory pupillary membrane (occlusio pupillæ). There is also an anterior capsular cataract.

is no good ground, either clinical or pathological, for the distinction, and the term *gummatous iritis* may be used for all these cases. There is generally much exudation in gummatous iritis, and broad synechiæ are formed. The nodules are liable to be mistaken for tubercle (*q.v.*) or sarcoma (*q.v.*) ; the absence of iritis and the presence of only a single nodule usually distinguishes the latter condition. Gummatous iritis may rarely extend to the corneo-sclera at the angle of the anterior chamber and lead to perforation of the globe.

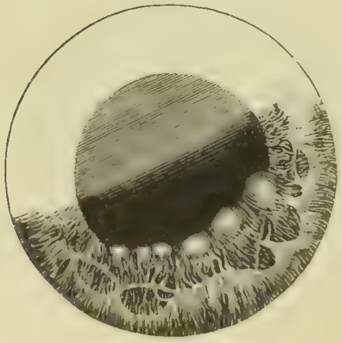


FIG. 151.—Nodules occurring in the secondary stage of syphilis, situated at the pupillary border of the iris. (Nettleship, from a drawing by W. G. Laws.)

Gonorrhœal Iritis is probably more common than is generally supposed. It occurs especially in those cases which have gonorrhœal "rheumatism," and seldom supervenes until after one attack of arthritis, usually in the knees. It exhibits no special signs : it tends to recur, often during the onset of a gleet or arthritic attack. There is little doubt that it is a metastatic infection. Another, more characteristic form may occur during the acute attack. The exudates into the anterior chamber then have a peculiar gelatinous appearance.

"*Rheumatic*" *Iritis.*—In patients with iritis, in whom no specific or gonorrhœal taint can be discovered, a history of rheumatic pains in the muscles and joints can often be elicited. Iritis seldom accompanies an attack of acute rheumatism, and only rarely can a history of such an attack be obtained. The patients are often gouty or have rheumatoid arthritis. What the pathological relationship of the iritis is to these complaints must remain a matter of conjecture until their ætiology is placed beyond dispute. The iritis in these cases is usually a plastic iritis

L) which, moreover, is extremely rare/

L The sites of previous gummatous deposits in the iris are evidently depigmentation of the ~~iris~~ stroma, probably owing to stretching. Whitish spots in the ciliary region of the iris, especially near the crypts, occur in the early stage of syphilitic infection without previous iritis. Syphilitic degeneration of the vessels causes thickening of the coats, sometimes making them appear as white lines. Atrophy of the muscle fibres, especially of the sphincter, also occurs, & a circle of atrophic patches near the pupillary border is strong evidence of syphilitic [illegible]

Vision is usually impaired permanently in syphilitic iritis. The prognosis is worse in the gummatous type. Specific iritis is indeed a sign of severe syphilis; Trousseau found that 34 out of 40 patients later developed grave sequelae such as tabes & general paralysis.

L The patients are almost always [illegible] [illegible] both eyes are affected, though not at the same time. Involvement of the [illegible] [illegible] may be indicated by fine vitreous opacities, but involvement of the choroid is very rare.

often attacks both eyes &

There is often an unusual amount of conjunctival & episcleral congestion. Iritis in an elderly patient inclined to be gouty, often starts suddenly in the night & sometimes ~~[illegible]~~ ushering in an acute attack of gouty arthritis.

of moderate severity. It shows a very marked tendency to recur, and the recurrence seems to bear a direct relationship to the recurrent attacks of pain or arthritis.

Diabetic Iritis is rare: it is probably a gouty iritis occurring in a diabetic subject. It shows a marked liability to the formation of new or enlarged vessels in the iris, with the formation of plastic exudates and occasionally an hypopyon. On the whole it runs a favourable course.

Tuberculous Iritis occurs in a miliary and a conglomerate or solitary form. In the former there is usually a yellowish white nodule surrounded by numerous smaller satellites: there is the same tendency as in gummatous iritis for the nodules to be near the pupillary or ciliary margins. In conglomerate tubercle there is a yellowish white tumour, though smaller satellites may be present. The nodules contain giant cells. There is usually less general iritis than in the gummatous form, but there is almost always some. The condition may be mistaken for gummatous iritis or for sarcoma. The absence of specific history, a negative Wassermann reaction, the failure of antisyphilitic treatment, and the age of the patients—children or young adults—are distinguishing features from gummatous iritis. The presence of satellites, the usual, but not invariable, absence of visible vessels upon the surface of the nodules, the age of the patient, and the presence of iritis distinguish it from sarcoma. The diagnosis may be extremely difficult, but the great rarity of sarcoma of the iris should be borne in mind (*vide* pp. 200—201). Simple iritis is said to be sometimes tuberculous: this form is ~~excessively~~ rare.

In conglomerate tubercle of the iris the corneo-sclera at the angle of the anterior chamber almost invariably becomes ultimately eroded and involved. The wall of the globe is thus weakened and eventually gives way. The tuberculous mass then grows rapidly through the perforation, and a large portion of the iris may become prolapsed. In this manner the eye is inevitably lost.

Sympathetic Iritis.—See Sympathetic Ophthalmia, Chap. XXI.

"*Serous*" *Iritis.*—See p. 299.

Secondary Iritis: Purulent Iritis.—See Chap. XXI.

Treatment.—Dilatation of the pupil with atropin and hot applications are the essentials of local treatment. Atropin acts in three ways: (1) by keeping the iris and ciliary body at rest; (2) by diminishing hyperæmia; (3) by breaking down posterior synechiæ and preventing the formation of fresh ones. It may be used in the form of drops of a 1 per cent. solution or as an ointment of the same strength. I prefer the ointment for the following reasons: (1) its action is more continuous; (2) it is easier to apply, since it usually works into the eye even if only rubbed along the lashes; (3) it is less likely to cause symptoms of poisoning, which are not uncommon with the drops in children. Symptoms of poisoning—dryness of the throat, flushing of the face, delirium, &c.—are due to the excess of solution—often considerable in unskilful hands—passing down the nasal duct into the nose and throat. The dose administered in this manner is never lethal.

Atropin should be pushed in the early stages, best by frequency of application rather than increased strength. Every four hours is usually sufficient. When the pupil is well dilated, two or three times a day suffices. If atropin irritation ensues, hyoscin, scopolamin, or duboisin should be substituted.

Hot applications are extremely grateful to the patient, diminishing the pain, and are of therapeutic service in encouraging a more vigorous blood and lymph flow. Hot fomentations and bathings may be used, but dry heat applied to the surface of the closed lids has the same

The von Pirquet cutaneous reaction ~~should~~ may be applied in doubtful cases. A positive result is of little value except in children, but a negative result eliminates the diagnosis of tuberculosis with a fair degree of certainty. Wolff-Eisner or Calmette's conjunctival test should not be used on account of the danger of severe reaction. Subcutaneous injection of Koch's old tuberculin gives a characteristic rise in temperature, etc. in the presence of tuberculosis, but there is no proof that the ocular lesion is the cause of the reaction & the test is not free from danger.

[illegible] $\frac{1}{4}$ to $\frac{1}{2}$ per cent solution

(81)

/ to the intramuscular injection of Lambkin's cream / / Salvarsan, galyl, &c,
came rapid improvement, but these cases also respond well to mercury —
These drugs are /

/ but these must not be given simultaneously with injections of metallic mercury.

effect. It may be effected by means of a Japanese muff-warmer, which is bandaged over a pad of wool, previously well heated and applied to the eye. By this means the heat is considerable and continuous, with a minimum of trouble and discomfort.

In very severe cases, or when the pupil does not readily respond to atropin, depletion of blood from the temple should be resorted to. The best method is by two or three leeches applied a short distance outside the external canthus. They should not be too far from the eye, nor too near, for in the latter case much œdema of the lids may follow. Heurteloup's artificial leech may be used, but is not so efficacious.

If the pain is very intense a hypodermic injection of morphia may be given. Aspirin is very useful in relieving pain.

General treatment should be commenced by a smart saline purge, and the bowels must be kept freely open throughout the acute stage.

In other respects the general treatment depends upon the cause. In syphilitic iritis the patient is rapidly got under the influence of mercury, best by inunctions. ~~This is~~ most effectual in the cases occurring during the secondary stage, but should also be used in the gummatous form. Here ~~it is~~ supplemented by iodides. The infantile form of acute syphilitic iritis responds rapidly to mercury, but neither drug is very efficacious in the congenital type, and in this, as well as in the later stages of the other forms, general tonic treatment is indicated.

In other forms of iritis, where a rheumatic taint is suspected or where no satisfactory cause can be found, it is usual to order salicylic preparations, and they appear to do good, not only in these, but also in gonorrhœal and diabetic iritis.

In the convalescent stage smoked glasses are ordered—

for both eyes, especially on account of the consensual reaction to light.

Tuberculous iritis is treated by the same local applications as other forms. The usual constitutional treatment must be pushed. Improvement and even complete resolution have been recorded from the use of tuberculin injections.

Some authors consider that tuberculous iritis is generally the primary manifestation of the disease in the body. They therefore advocate the removal of the eye as soon as the diagnosis is made, in order that the danger of extension of the disease to other parts of the body may be minimised. If perforation of the globe has taken place and the eye is irretrievably lost immediate excision should be urged, but in other cases ordinary treatment, supplemented by tuberculin, should be persisted in.

Treatment of Sequelæ and Complications.—For the treatment of coincident cyclitis see p. 302.

Firm posterior synechiæ can sometimes be broken down by placing a small particle of solid atropin in the conjunctival sac. Care must be taken to prevent the dissolved atropin from passing down the nasal duct by pressure with the finger upon the lacrymal sac by the patient himself, but the surgeon must see that the pressure is rightly applied and kept up.

Annular synechia demands an iridectomy in all cases in order to restore communication between the anterior and posterior chambers, and thus avoid the supervention of secondary glaucoma (*vide* p. 308). No operative procedure of this kind must be undertaken during an acute or even the slightest attack of iritis if it can be possibly avoided, since the traumatic iritis set up will frustrate the object of the operation by filling the coloboma with exudates, and may even cause the loss of the eye. It is best, if possible, to forestall a ring synechia by performing the iridectomy

(82)

Atropin or its equivalent should be continued for at least 10 days or a fortnight after the eye appears to be quiet, otherwise a relapse is very likely to occur.

(83)

Good results have undoubtedly been obtained by the use of tuberculin & it should be given a persevering trial; nevertheless it often fails to ameliorate the condition.

It is often difficult to get a good [illegible] owing to the [illegible] & friability of the [illegible] & the firmness of the adhesions. Haemorrhage is common & the [illegible] [illegible] then [illegible] to be abandoned.

before the adhesion extends round the whole circle. This can often be done, because operable ring synechia, *i.e.*, ring synechia without total synechia, is frequently the result of recurrent attacks of quiet or almost painless iritis, during each of which more of the circle is involved. The iridectomy is performed during a quiescent interval.

Total posterior synechia can seldom be operated upon with success. Iridectomy is seldom possible, and the only procedure which can be adopted is extraction of the lens by a specially devised operation. Iridectomy or iridotomy may be possible if the lens is shrunken.

Cyclitis has already been referred to incidentally. The exudates from the ciliary body pass into the anterior chamber directly from that part which forms a boundary of the chamber (Fig. 2), and by passing forwards through the pupil. When they organise in the plastic form they not only cause total posterior synechia, but also surround the lens and extend throughout the vitreous. Behind the lens they form a transverse membrane or cyclitic membrane. Strands of fibrous tissue are formed in the vitreous. They become anchored to the retina in various places, and by their subsequent contraction often lead to detachment of the retina. The exudates which organise upon the surface of the ciliary body cause the destruction of the ciliary processes, which results in abolishing or seriously diminishing the secretion of aqueous. Hence the intraocular tension becomes lowered and the eye is quite soft to the touch. The walls of the globe fall in, and the eye becomes shrunken—*phthisis bulbi* (φθίνω, to waste) (Fig. 152). After this has occurred degenerative changes supervene, and the choroid becomes converted after months or years into bone.

Chronic Irido-cyclitis (*Syns.—Simple Cyclitis*, "*Serous Iritis*").—This is an extremely insidious and chronic disease, characterised by diminution of vision with slightly marked physical signs. In severe cases there is ciliary congestion, tenderness on pressure over the ciliary region, deep anterior chamber, precipitates ("keratitis punctata") on the back of the cornea, and dust-like opacities in the vitreous. The tension is usually slightly raised in the earlier stages, lowered in the later. There may be œdema of the upper lid and neuralgic pain in the eye and brow.

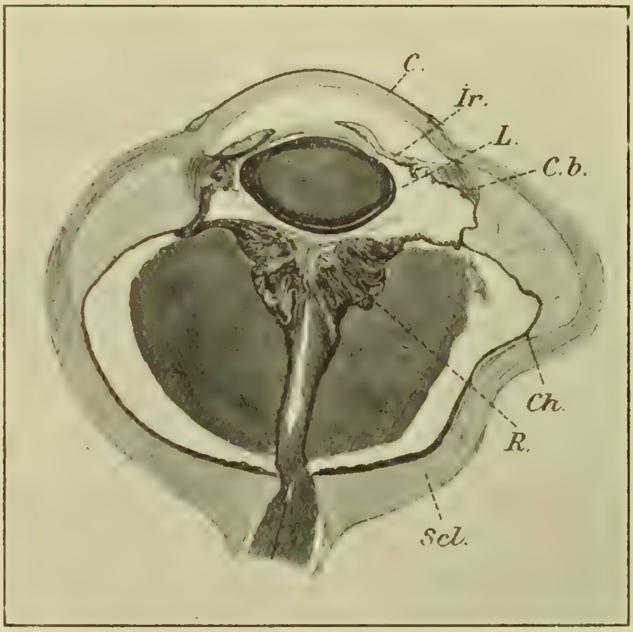


FIG. 152.—Phthisis bulbi, due to irido-cyclitis (× 3). *C*, cornea; *Ir.*, iris; *L*, lens; *C.b.*, ciliary body; *Ch.*, choroid; *R*, retina, detached and folded up behind lens, separated from choroid by albuminous coagulum; *Scl.*, sclerotic.

There is sometimes myopia, owing to irritation of the ciliary muscle.

The *keratic precipitates* ("k.p.") (Fig. 153) consist of leucocytes which are deposited from the aqueous upon the back of the cornea and stick there. They may contain pigment granules, showing their origin from the uveal tract (pigmented k.p.). In the most characteristic form they are scattered over a triangular area of the lower part of the cornea, the smaller spots being above, the larger below

Posterior synechiae are not a conspicuous feature, but are liable to be formed slowly & insidiously.

(95)

[illegible] thus be distinguished from

1 Pigmented spots are sometimes simple [illegible] [illegible] They are more likely to contain
opacities in the deeper layers of the cornea. [illegible] also occurs
pigment after the [illegible] "pigmented [illegible]" lasts a long time. Pigmented in
[illegible] [illegible] duration of the disease. The
[illegible] [illegible]
pigmented [illegible] [illegible]

(Fig. 153). This arrangement is due to gravitation of the particles towards the bottom of the anterior chamber, combined with the perpetual movements of the eye, which are mostly in the horizontal direction. The typical arrangement is often but not always observed. More commonly a few isolated spots are seen scattered irregularly over the lower part of the cornea. They require great care in examination for their discovery (*vide* p. 101), and their importance cannot be over-estimated. The smaller spots frequently coalesce, forming small plaques, which gradually become more translucent ("mutton-fat k.p."). Similar ~~spots~~ are rarely seen upon the anterior capsule of the lens, but the leucocytes do not readily stick here owing to the smooth surface, devoid of endothelium.

The vitreous opacities are of the same nature, viz., wandering leucocytes, but many are also probably minute particles of albuminous exudate. Their mobility in the vitreous shows that the consistency of this substance has undergone change, sometimes amounting to complete fluidity, and is due to defective nutrition.

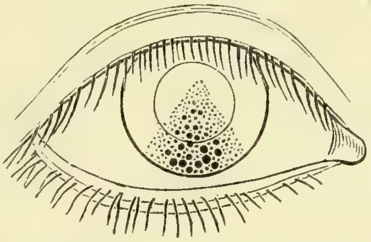


FIG. 153.—Typical arrangement of spots on the back of the cornea in "keratitis punctata" (k.p.). (Nettleship, from a sketch by Dr. Herringham.)

The depth of the anterior chamber is an important sign, not easily explained. It is undoubtedly connected with the deficient filtration of the albuminous aqueous through the angle, which also accounts for the rise in tension. The peripheral part of the anterior chamber is often particularly deep, even deeper than the central: this is however more marked in the later stages of plastic cyclitis, when it is due to mechanical retraction of the iris from organisation of exudates in the posterior chamber.

In the slightest and most insidious cases of irido-cyclitis the symptoms and physical signs are minimal. Considerable diminution of vision without obvious cause should always excite apprehension, and the cornea should be most carefully explored by oblique illumination with magnification by the loupe, as well as by the direct method with a strong convex lens. A few spots of k.p. are decisive proof of cyclitis, and may be the sole physical sign. Change in the colour of the iris, due to atrophy, is an important sign, since it may at once attract attention.

Chronic irido-cyclitis occurs under similar conditions to simple iritis. Syphilis may be the cause. It is probably always due to some form of toxæmia or bacterial metastasis, and a careful search should be made for a septic focus in some part of the body. It is most frequently found in the mouth—pyorrhœa alveolaris—in the nose and accessory nasal sinuses, or, especially in women, in the genital tract. Very often no such source of toxins can be demonstrated, but the patients are usually of a debilitated type. There is often constipation, and it is not improbable that the intestinal tract is a frequent source of the toxins.

The disease is generally very chronic and liable to exacerbations with gradual and insidious formation of posterior synechiæ. Vision is greatly diminished during the more acute stage, but recovers considerably in the intervals, but each recurrent attack leaves more and more permanent defect. The eye may finally become soft and tender, and enter into the condition of phthisis bulbi, but this ~~usually~~ occurs only after many years in simple cases of irido-cyclitis. Less serious cases, however, not uncommonly occur, especially when the septic focus, *e.g.*, pyorrhœa aveolaris, is discovered and is amenable to radical treatment.

Treatment of irido-cyclitis is essentially the same as that

[It is commoner in women than in men] [particularly]

Septic foci such as pyorrhoea alveolaris, nasal, genital or urinary sepsis, furunculosis, &c, must be radically treated when possible. In some cases an autogenous vaccine has produced rapid cure, but it more often fails.

Small doses of calomel (gr. 1/4, three times a day), or sodium salicylate, ~~[illegible]~~ do good in many cases of obscure aetiology, possibly by acting as intestinal disinfectants. Iodides help to cause absorption of inflammatory exudates in severe ~~[illegible]~~ cases.

of iritis, but special attention must be directed to any septic foci which may be found and to the general health. The cases often drag on indefinitely, with occasional exacerbations. During the more acute phases energetic treatment with atropin, hot bathings or the muff-warmer, and if necessary blisters or leeches, is indicated. The patient should be kept in bed and submitted to mercurial inunctions or baths, which often do good in cases in which there is no specific history. Diaphoresis by vapour baths and hypodermic injections of pilocarpin may be tried in intractable cases, which form the majority.

If the intraocular tension is raised seriously, so that there is danger to the sight of the eye from this cause, it must be relieved by paracentesis (*vide* p. 237). It usually has only a transitory effect, and may require to be repeated every two or three days. It is theoretically unsatisfactory, since the comparatively sudden reduction of the intraocular pressure to zero causes dilatation of the ciliary vessels and allows the passage of a lymph which is even more albuminous than that which has been let out. It should therefore not be resorted to unless imperatively indicated. On the other hand the final result is often very satisfactory, probably because the rapid flow of lymph flushes out the secretory channels and carries away endothelial and epithelial débris and stagnant toxins.

During the intervals between exacerbations the pupils should be kept moderately dilated with weak (0·5 per cent.) atropin. The patient should have plenty of fresh air, good diet, and tonics.

If the eye becomes useless, shrunken, and painful it may be necessary to excise it.

Plastic Irido-cyclitis.—The pathology of this condition has already been described incidentally. In it the signs of irido-cyclitis in general are increased. The cyclitic membrane behind the lens may be seen with the ophthalmoscope or even by oblique illumination. In young children the condition forms one type of pseudo-glioma (Chap. XIX.). In the later stages the degenerative changes in the ciliary body prevent it from fulfilling its functions of supplying the eye with lymph and nutriment. The vitreous suffers first, and later the lens, which becomes opaque. Finally the eye shrinks (phthisis bulbi).

Treatment is the same as for chronic irido-cyclitis. The blind, shrunken globe is often painful and a continual source of annoyance to the patient. It should, under these circumstances, be excised.

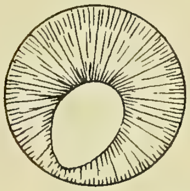


FIG. 154.—Congenital coloboma of the iris.

Purulent Irido-cyclitis.—See Chap. XXI.

Sympathetic Irido-cyclitis.—See Chap. XXI.

CONGENITAL ABNORMALITIES OF THE IRIS.

One iris may have a different colour from the other, or parts of the same iris may differ in colour. Both conditions are known as *heterochromia iridis.*

The pupil is normally slightly to the inner side of the centre of the cornea. In some cases it is considerably displaced, usually also to the nasal side—*corectopia* (κόρη, pupil, ἐκ, out of, τόπος, place). Rarely there are other holes in the iris besides the pupil—*polycoria.*

The iris may be apparently absent—*aniridia* or *irideremia.* Anatomical investigation has shown that there is always a narrow rim persistent at the ciliary border, but it is hidden from view during life by the sclerotic. On examination the ciliary processes and the suspensory ligament of the lens can be seen. Aniridia is usually bilateral. There is a tendency for secondary glaucoma to develop in these eyes.

(88) Gumma of the Ciliary Body causes an intense acute plastic irido-cyclitis, with severe iritis, much exudation into the anterior chamber, often deep infiltration of the cornea & usually great pain. It is a rare complication of syphilis, not confined to the tertiary stage. It varies in the severity of the symptoms & the rate of progress. It is only to be diagnosed (with certainty) clinically when ~~it~~ the inflammation extends into the sclerotic (v. p. 280). If it does not respond to active anti-syphilitic treatment the eye eventually shrinks.

Tubercle of the Ciliary Body occurs with ~~tuberculous iritis & choroid~~. ~~itis~~ tubercle of the iris & of the choroid & is usually only inferred clinically rather than definitely diagnosed. As already mentioned the tubercle bacillus may account for some cases of chronic cyclitis.

There may be a gap in the iris, usually pear-shaped or like a gothic arch, continuous with the pupil and extending towards, but not always as far as, the ciliary border. It is called a *congenital coloboma* (κολόβωμα, mutilation) of the iris (Fig. 154). It is usually downwards or down and slightly in, corresponding with the position of the fœtal, so-called choroidal cleft: such a coloboma is called typical. Colobomata are found in other directions, and are then called atypical. Typical coloboma of the iris is often associated with typical coloboma of the choroid (*q.v.*). It is one of the commonest congenital malformations of the eye.

Persistent Pupillary Membrane is due to persistence of part of the anterior vascular sheath of the lens, a fœtal structure which normally disappears shortly before birth. Fine threads stretch across the pupil, or may be anchored down to the lens capsule (Plate VI., Figs. 3, 4). They are distinguished from post-inflammatory synechiæ in always coming from the anterior surface of the iris just outside the pupillary margin, *i.e.*, from the position of the corona or circulus iridis minor. Such tags are of frequent occurrence and are of no pathological importance. They are commonest in young children and probably undergo further absorption as age advances.

The foetal pupillary membrane consists of a system of minute bloodvessels supported by a very delicate stroma which contains pigment cells. Sometimes the pigment is left on the lens surface. This commonly appears as a multitude of very fine brown dots scattered over a circular area ~~[illegible]~~ [illegible] in diameter in the centre of the pupil. These spots are distinguished from pigment spots left by posterior synechiae which have broken down (v. p. 290) in being much more numerous, & very regularly arranged, & also by the absence of any [illegible] of iritis. They do not necessarily interfere appreciably [illegible] with vision.

CHAPTER XIV.

GLAUCOMA.

Glaucoma is a symptomatic condition, not a disease *sui generis.* The characteristic symptom, or rather physical sign, is increased intraocular pressure. It will be clear from the description of the mechanism whereby the normal intraocular pressure is maintained (*vide* p. 18) that increase may be due either to (1) increased production of lymph associated with normal or diminished outflow, or to (2) diminished outflow associated with normal or increased inflow. Though the factors which bring about increased production of aqueous cannot be eliminated, yet it may be taken as certain that pathological increase of tension is almost invariably due to defective outflow.

Two great classes of cases in which the tension is pathologically increased can be distinguished, viz., (1) those in which the tension is only moderately increased, in which the anterior chamber is deep, and in which there are more or less definite signs of inflammation of the ciliary body (Chap. XIII.); and (2) those in which all grades of increased tension are met with, in which the anterior chamber is shallow, and in which, though there may be very evident signs of congestion and irritation, any definite signs of ciliary inflammation are either absent or secondary in onset. It is well to keep these two groups quite separate, since their pathogenesis is different and the differences in clinical course and treatment are marked. The term glaucoma should be limited to the second group.

True glaucoma may be conveniently divided into two

PLATE VIII.

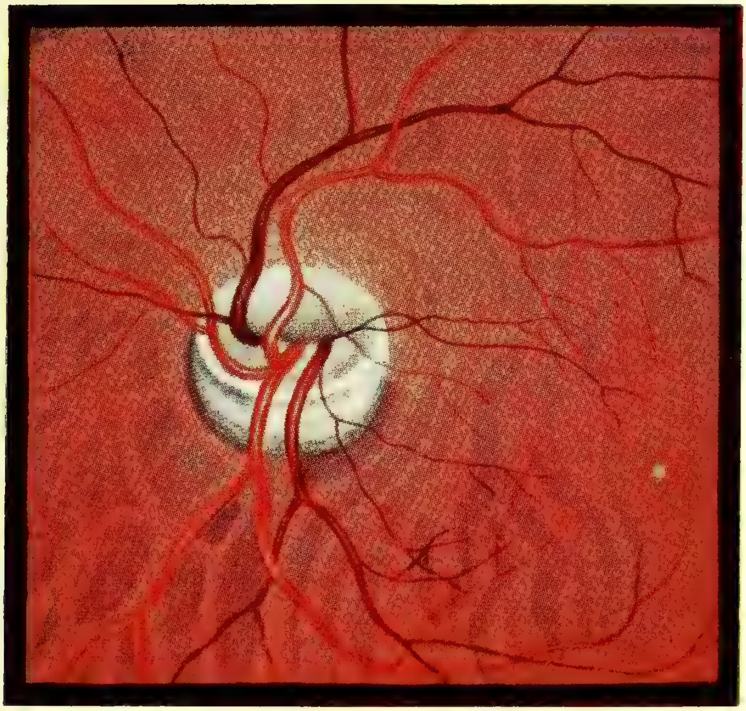


Fig. 1.

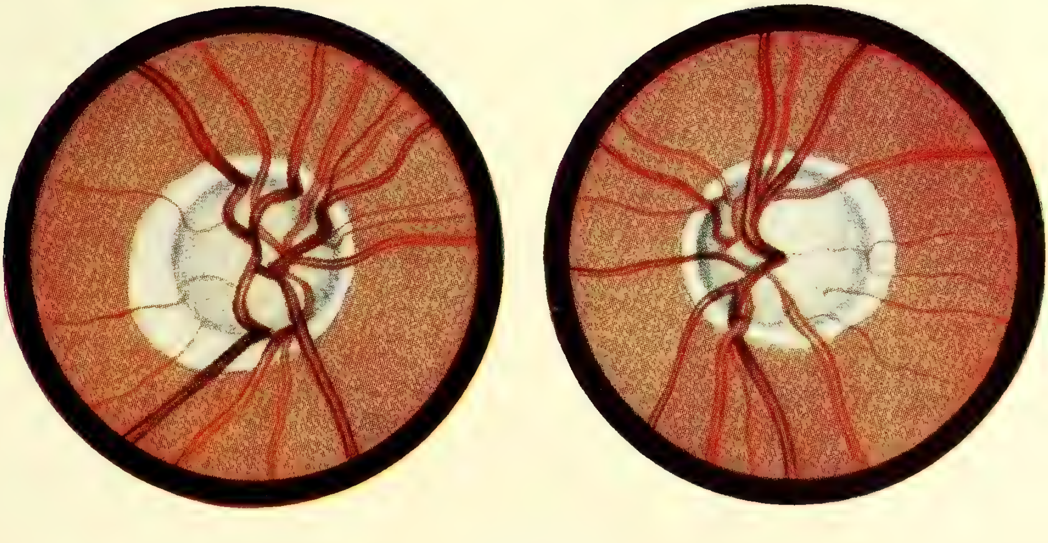


Fig. 2.

forms, primary and secondary. Primary glaucoma, acute and chronic, has been called idiopathic, since it comes on without any apparent fundamental cause. Since the pathology of secondary glaucoma has been fairly well elucidated and throws some light upon that of primary, the former will be considered first.

Secondary Glaucoma.—We have seen that the increased tension of irido-cyclitis is due to defective filtration of the aqueous at the angle of the anterior chamber owing to the viscous nature of the fluid. Secondary glaucoma is almost invariably due to mechanical obstruction at the same spot. Usually the obstruction takes the form of adhesion of the iris to the back of the corneo-sclera. This peripheral anterior synechia causes the obliteration of the network of the ligamentum pectinatum iridis, and prevents the fluid from gaining access to the canal of Schlemm. It is therefore imprisoned within the eye and the intraocular pressure rises. In order that this may occur it is necessary that the angle should be obliterated over a considerable part of its circumference, but there is a great tendency in most cases for the cause which has produced partial peripheral anterior synechia eventually to complete the circuit. In some cases in which secondary glaucoma supervenes there is no actual synechia, but the meshes of the ligamentum pectinatum are choked with leucocytes, pigment granules, fibrin, &c., so that filtration is inefficient.

Though peripheral anterior synechia is undoubtedly the immediate cause of secondary glaucoma, it is itself produced by a variety of conditions, most of which are various forms of anterior or posterior synechia.

When an anterior synechia is formed the plane of the iris is advanced, so that the angle of the anterior chamber on this side is made more acute than normal. The cause which led to the formation of the synechia also causes iritis, usually of the traumatic type. Traumatic iritis is merely a plastic iritis due to injury. In it much exudation is poured out, possessing great tendency to organise. It collects in the diminished angle and becomes transformed into fibrous tissue, which welds the iris and corneo-sclera together, thus producing a peripheral anterior synechia, which may be strictly localised, so that no secondary glaucoma supervenes. Such eyes however are liable to fresh attacks of iritis, often of an insidious character. Each attack is followed by further occlusion of the angle, until finally the amount remaining open is insufficient to carry out efficient filtration and the tension rises.

The chief causes of secondary glucoma are the following.

(1) *Perforation of the cornea with anterior synechia.*—The ~~perforation~~ may be an operation ~~wound~~, *e.g.*, extraction of cataract, for a peripheral section through the corneo-scleral margin or actually in the sclerotic near the margin has a similar effect to a wound in the cornea. The synechia need not necessarily be of iris, but after cataract extraction is often one of the lens capsule, which has the same effect of advancing the contiguous parts of the iris and obliterating the angle. Secondary glaucoma after operations may also be due to other causes.

(2) *Annular posterior synechia* (*vide* p. 287).—This acts by interposing an impermeable barrier between the posterior and anterior chambers. The lymph secreted by the ciliary body is thus prevented from passing forwards into the anterior chamber. The iris becomes bowed forwards—bombé—and the periphery becomes apposed to the corneo-sclera, where it later becomes adherent. The aqueous is thus unable to escape from the eye and the tension rises. If the condition is not relieved by operation secondary glaucoma causes blindness. The prolonged high tension then causes degeneration of the ciliary processes, which ceases to produce so much fluid, so that finally the tension may be normal or even sub-normal, and the eye may shrink. The

The perforation may be due to an ordinary perforating wound of the cornea with ~~prolapse of iris~~ incarceration of iris in the wound or it may be due to perforating ulcer of the cornea –

Moreover the swollen lens matter in the aqueous impedes filtration through such part of the angle of the anterior chamber as remains open both mechanically & also by increasing the albuminous contents of the aqueous.

condition is relieved by iridectomy, or if this is impossible, by iridotomy, communication between the posterior and anterior chambers being thus restored.

(3) *Wound of the lens.*—When the lens is wounded it swells (*vide* p. 447), and pushes the iris forwards into contact with the corneo-sclera. Mere apposition is sufficient to produce permanent secondary glaucoma, which should at once be relieved by operation (*vide* p. 448). If it is not performed the iris becomes adherent to the corneo-sclera and the glaucoma becomes permanent, although the lens may be eventually absorbed.

(4) *Dislocation of the lens.*—This may be complete through the pupil into the anterior chamber. It then blocks the angle, especially if the iris is firmly contracted against its posterior surface. Partial lateral dislocation of the lens causes it to push forwards the iris on the side towards which it is dislocated. Since the circle of the equator of the lens is not much smaller than that of the angle a considerable portion of the latter is blocked, and secondary glaucoma supervenes.

(5) *Intraocular tumour.*—The mechanism whereby this produces secondary glaucoma will be described later (*vide* p. 415).

(6) *Intraocular hæmorrhage.*—Severe intra-vitreous or sub-choroidal hæmorrhage forces forwards the vitreous and lens, so that the iris is pushed into contact with the cornea. It also acts by filling the eye with highly albuminous fluid which filters with difficulty. If the vessel which has ruptured is large the tension may be raised to that of blood pressure.

A special type of glaucoma is sometimes met with after retinal hæmorrhage, which may be due to some unknown cause or to thrombosis of the central vein (*q.v.*). It is probably caused by mixture of the lymph with albuminous fluids. Such cases are sometimes grouped together under the designation *hæmorrhagic glaucoma*, a term which is however best avoided. They may be indistinguishable from primary glaucoma if not seen until the media are too opaque for ophthalmoscopic examination. Iridectomy is likely to be accompained by severe hæmorrhage, and is therefore contraindicated.

Primary Glaucoma.—The cause of primary glaucoma is unknown. The most probable theory is that of Priestley Smith, who attributes the preponderant *rôle* to the lens. It has already been pointed out (*vide* p. 11) that the lens continues to grow throughout life. The space between the equator of the lens and the ciliary processes, the circumlental space, will therefore become smaller as the patient becomes older. If the eye is small the space may become so diminished that slight congestion of the ciliary processes may bring them in contact with the lens. The effect will be to prevent the fluid which is secreted by the ciliary body from passing forwards through the pupil. The lens will therefore be forced forwards, and will push the iris in front of it, making the anterior chamber very shallow, and bringing the periphery of the iris in contact with the corneo-sclera. In this manner the filtration angle will be occluded and glaucoma will supervene. If the condition persists an acute attack of glaucoma is caused. If the occlusion of the angle is not complete a subacute attack is caused, and the spontaneous diminution of the congestion of the ciliary body may relieve the condition. The onset of fresh congestion leads to another attack, and thus chronic glaucoma is brought about. It will be seen from what follows that the facts fit in very well with this theory.

Primary glaucoma is essentially a disease of late adult or advanced life. It is commonest in women, who are more liable to venous congestion in various parts of the body. Hypermetropic eyes are more susceptible than those with normal or myopic refraction ; in fact, primary glaucoma is [h It usually occurs after fifty years of age & is very common in Jews. It is sometimes hereditary, & in these cases ~~shows~~ affords examples of "anticipation" (Nettleship), i.e. it occurs at an earlier age in each succeeding generation.

rare in myopic eyes. This has been shown to be due not to the hypermetropia *per se*, but to the smallness of the eyes. In order that an eye may be hypermetropic it is not necessary for it to be small, but as a matter of fact hypermetropic eyes usually are small. It has been found that the size of the cornea is a good criterion of the size of the ring formed by the ciliary processes, *i.e.*, of the circumlental space. The size of the lens varies little in different eyes of patients of the same age. It follows, therefore, that an eye with a small cornea will probably have a small circumlental space, and will be very liable to glaucoma.

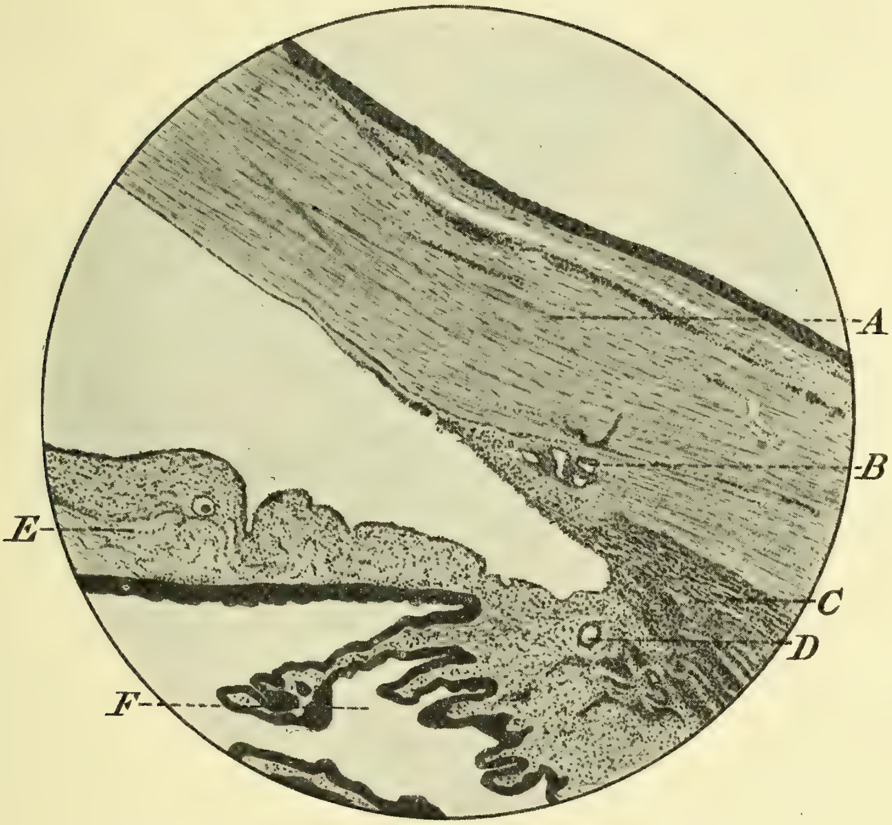


FIG. 155.—Normal angle of anterior chamber.

As age advances the anterior chamber becomes shallower. If the cornea is small this will have the effect of diminishing the size of the angle of the anterior chamber. Filtration is carried out less easily when the meshes of the ligamentum pectinatum iridis are crowded together than when they are widely separated. In these eyes a very slight further diminution of the angle may bring on an attack of glaucoma. Thus, the mere dilatation of the pupil with a mydriatic, by folding up the iris so that it is crowded into the angle, may suffice to occlude it entirely; hence the extreme danger of instilling a mydriatic into the eyes of elderly people, especially if they are hypermetropic or have small corneæ and shallow anterior chambers.

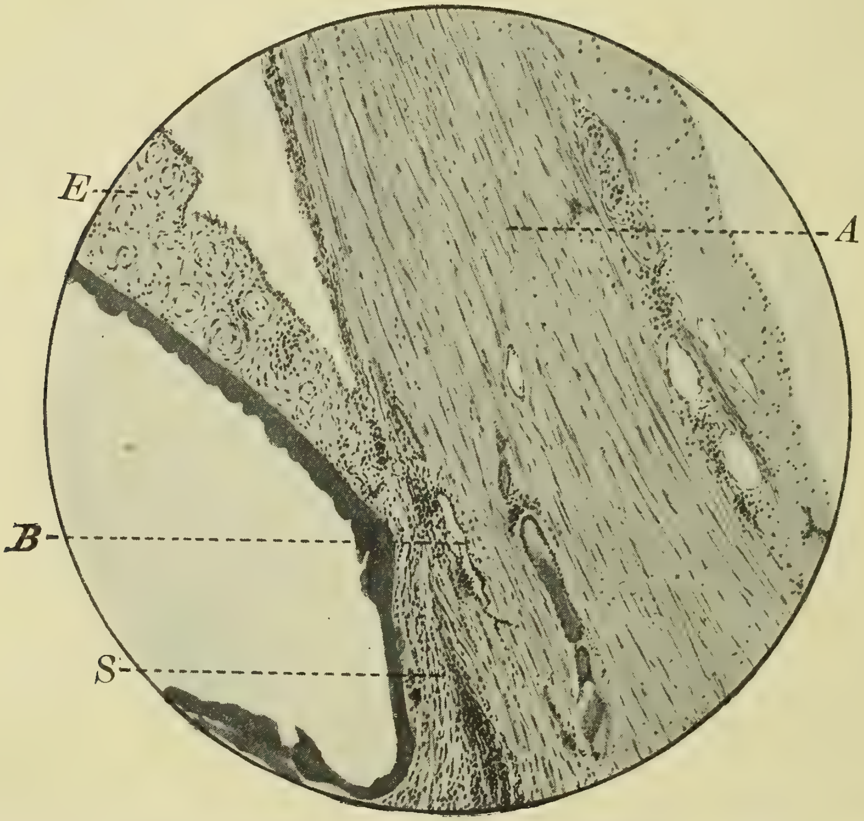


FIG. 156.—Peripheral anterior synechia (*S*), causing blockage of the filtration angle. *A*, cornea ; *B*, canal of Schlemm ; *E*, iris.

Since both eyes usually have a similar structure, glaucoma is likely to be bilateral, but one eye is often affected before the other.

The anatomical effects of pathological increased intraocular pressure are as follows. The already shallow

[k] Moreover the *fibres* of the ligamentum pectinatum tend to become thickened & sclerosed in elderly people.

anterior chamber is made still more shallow. In an early acute attack the periphery of the iris is merely apposed to the corneo-sclera. In the later stages and in chronic glaucoma of some standing it is firmly adherent. The longer the condition has lasted the firmer is the union. The iris is first bound down by organised exudate; later, the iris stroma atrophies and the inner wall of Schlemm's canal, which may be almost obliterated, is covered only by degenerated retinal pigment epithelium. Anterior to this a "false" angle is formed where the iris leaves the cornea; no filtration can take place either through the peripheral anterior synechia or through the false angle.

The part of the eye which suffers earliest and most from the increased pressure is the head of the optic nerve. The lamina cribrosa, which is more resistant than the nerve tissue, is less resistant than the sclerotic. Hence it becomes pushed backwards, the nerve fibres being depressed also. The first manifestation of the effects of pressure is a bowing backwards of the connective tissue which forms the lamina cribrosa, so that it becomes concave anteriorly instead of passing straight across the porus opticus. This effect continually increases, until the lamina cribrosa is displaced backwards as a whole. Meanwhile the nerve fibres have been pressed together, so that the papilla becomes flat or depressed. The pressure causes the nerve fibres to atrophy, so that finally the lamina cribrosa is exposed upon the surface. In the final stage a deep cup is formed, generally having overhanging edges.

Pulsation of the arteries at the edge of the disc is often seen in glaucoma. Whilst venous pulsation is of little importance spontaneous arterial pulsation is always pathological (*vide* p. 150). It is not always spontaneous in glaucoma if the tension is not very high, but even then it is induced by very slight pressure of the finger through the lid. The arterial pulsation is due to the increased pressure upon the walls of the vessels, so that the intravascular pressure is only able to force blood through at the height of the cardiac systole.

Other parts of the eye show less change. The pressure causes degeneration of the nerve fibre layer of the retina. The choroid becomes degenerated and thinned, only the larger vessels remaining. The ciliary body becomes degenerated in the last stages, after which the tension may cease to be raised owing to defective secretion of lymph.

The physiological effects of pathological increased intraocular pressure are manifold. Pain is complained of, due to stretching of the sensory nerves of the eye. The patient sees coloured haloes round lights; these are due to alteration in the refractive conditions of the corneal lamellæ. The pupil becomes slightly dilated and immobile, owing probably to œdema and pressure on the ciliary nerves as they run through the choroid. Rapid diminution in the amplitude of accommodation may be a prominent feature, so that there is an apparent increase in presbyopia. It is attributable to pressure on the ciliary nerves and on the ciliary muscle. Diminution of vision is due to cloudiness of the media, retardation of the blood flow, and pressure on the nerve fibres in the retina and optic papilla. Cloudiness of the media affects the cornea principally, and is due in the early stages to altered refractive conditions, in the later to œdema. Pressure on the nerve fibres first affects the temporal side of the retina, and therefore the

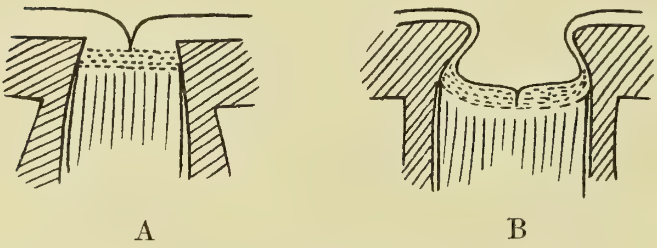


Fig. 157.—A, diagram of meridional section of normal disc; B, diagram of meridional section of glaucomatous cupped disc. Note the displacement backwards of the lamina cribrosa.

nasal side of the field. Later, the field becomes contracted in all directions, and central vision is depressed. Finally, vision is abolished, owing to total atrophy of all the fibres.

Acute Glaucoma.—In even the most acute cases of glaucoma careful inquiry will often elicit prodromal symptoms. Transient attacks of obscuration of vision, as if a cloud were in front of the eye, have occurred. Bright lights have appeared to be surrounded by rainbow haloes. A feeling of discomfort in the eye and neuralgic headache accompany these symptoms. Such attacks become more frequent, come on especially at night and after excitement or worry. It is noticed that stronger glasses are required for near work. This condition may extend over months or years.

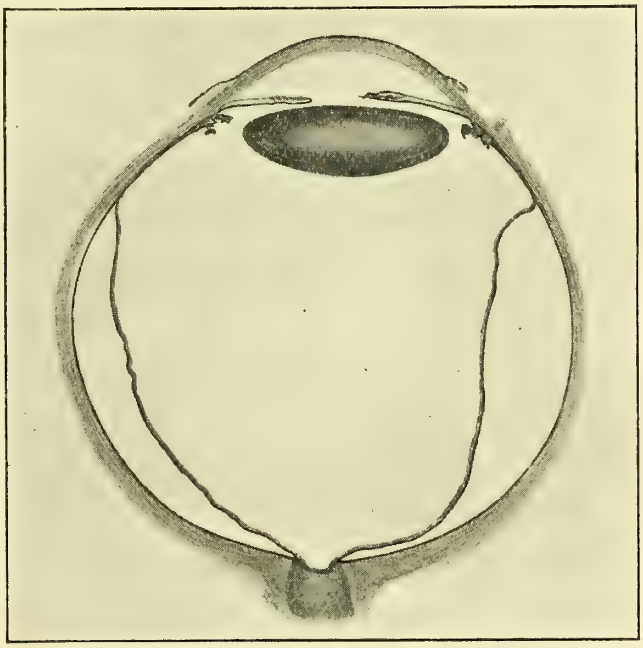


FIG. 158.—Horizontal meridional section of a glaucomatous eye.

If the patient is examined whilst the symptoms are present it will be found that there is a slight haziness of the cornea, so that it looks bluish, like glass that has been breathed upon—hence the term glaucoma (γλαυκός, sea green). If the field of vision is taken between the attacks some slight contraction of the nasal field will be found, but central vision may be perfect.

The acute attack sets in suddenly. It may be due to some condition inducing venous congestion, *e.g.*, constipation, menstruation, over-feeding, alcohol, &c., or to worry, fatigue, a recent illness, or to the instillation of a mydriatic. Intense pain is felt in the eye and over the distribution of the fifth nerve. The pain is frequently so bad that it causes vomiting, and the attack is liable to be mistaken for a severe "bilious attack." The temperature may be raised. The vision rapidly diminishes, so that in a few hours only hand movements can be recognised.

Objective examination shows some œdema of the lids and conjunctiva; the latter is intensely congested and looks dusky red, owing to the dilatation of the veins. Ciliary congestion is marked. The cornea is cloudy and insensitive to the touch. The anterior chamber is very shallow. The iris is discoloured, the pupil moderately dilated and oval, generally with the long axis vertical. The reactions to light and accommodation are abolished. Ophthalmoscopic examination is impossible owing to the cloudiness of the cornea. The tension of the eye is considerably raised.

There is no true inflammation in the early stages, so that the term inflammatory glaucoma, frequently used, is inadvisable; it should be replaced by *congestive glaucoma.*

If the condition is not relieved by operation, the amount of permanent diminution of vision depends upon the severity and duration of the acute attack. Total abolition of vision may result. More frequently improvement occurs, ushered in by diminution of pain. Considerable lowering of the visual acuity, and, still more, contraction of the field follows every acute attack. All grades, indeed, may be met with, from the mild prodromal attacks to the severest, with complete blindness. The tension remains permanently slightly elevated. Some congestion and irritability persists. The pupil reacts sluggishly, and the iris shows signs of atrophy, usually first in one or more

L The constitutional disturbance is often so great that the patient is prostrated, the pulse becoming irregular & intermittent.

L In a considerable number of cases both eyes are affected almost simultaneously.

sectors. Ophthalmoscopic examination now becomes possible. Cupping of the optic disc may or may not be found, according to the duration of the raised tension before and after the acute attack. A single acute attack is not followed by cupping immediately, for this demands more or less prolonged high tension.

In every disease of one eye the other should be thoroughly examined. In acute glaucoma it may be found that chronic glaucoma has existed long unobserved in the other eye, and well marked cupping of the disc may be present. The same causes which induced the acute attack in one eye may rapidly induce a similar attack in the other. The pain and worry associated with preparations for operation and so on increase the danger. This eye should therefore be carefully watched, and prophylactic measures adopted. It is usually sufficient to instil a drop of 1 per cent. solution of eserin in the sound eye every day so as to keep the pupil contracted.

It is of the utmost importance that pathological cupping of the disc should always be recognised when present (Plate VIII., Fig. 2). It differs in ophthalmoscopic appearance from a deep physiological cup, with which it is most likely to be confounded, in that the excavation reaches to the edges of the disc and the sides are steep, not shelving. The retinal vessels have the appearance of being broken off at the margin of the disc. If they are accurately focused here their continuations upon the floor of the cup are slightly out of focus and look broader and paler. When the edges overhang, as is often the case, the course of the vessels as they climb the sides of the cup is hidden. By the indirect method slight lateral movement of the large lens causes a distinct parallax (*vide* p. 138), which is more marked the deeper the cup. By the direct method the difference in level between the vessels at the edge and on the floor can be measured (*vide* p. 142).

There is always some atrophy of the optic nerve when the disc is cupped by the glaucomatous process; it is therefore not surprising that there may be great difficulty in distinguishing a shallow glaucoma cup from the slight depression which follows simple atrophy of the nerve without increase of tension (*vide* p. 409). If the cup is deep and total it is certain to be glaucomatous. In shallow glaucomatous cups the disc has a pink colour, whereas the atrophic cup is white. In many early cases all the conditions have to be weighed carefully before it is possible to come to a definite conclusion; the field of vision usually affords the most important criterion, the contraction being chiefly nasal in early glaucoma, concentric in optic atrophy.

The final stage of the untreated disease is *absolute glaucoma.* The eye is completely blind. The anterior ciliary veins are dilated, and a reddish blue zone surrounds the cornea. The cornea is clear, but insensitive; it may have vesicles (bullous keratitis) or filaments (filamentary keratitis) upon it. The anterior chamber is very shallow. The iris is dilated, atrophic, and may have a broad zone of pigment around the pupil (ectropion of the uveal pigment). The pupil is grey or greenish, instead of jet black. The optic disc is deeply cupped. The tension is high; usually the eyeball is as hard as stone.

Such an eye is generally painful, with temporary exacerbations, though patients often prefer to bear the pain rather than submit to excision. If it is still retained degenerative changes occur. The more important are due to giving way of the sclerotic before the continued high intraocular pressure. In this manner scleral staphylomata are produced. They may be in the neighbourhood of the ciliary body—ciliary staphylomata, or at the equator—equatorial staphylomata.

Anatomical investigation shows that *ciliary staphylomata*

are of two kinds. In one, the region where the iris is adherent to the corneo-sclera gives way (Fig. 159). These are called *intercalary staphylomata* (Fig. 160). In them the iris projects into the anterior chamber from an attachment at the anterior margin of the staphyloma, whilst the ciliary body, little altered, forms the posterior margin. The other form is the true *ciliary staphyloma* (Fig. 161). In them the region of the ciliary body itself gives way, so that it becomes spread out over the inner surface of the ectasia. In many cases both parts becomes ectatic.

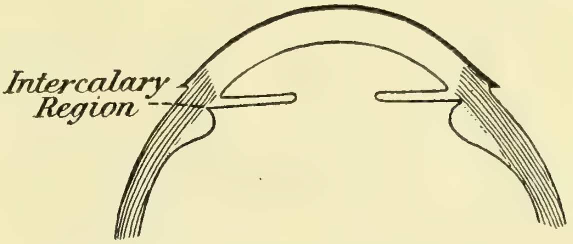


FIG. 159.—Diagram showing intercalary region.

Clinically it is impossible to distinguish between these forms.

Equatorial staphylomata can only be seen clinically when the eye is turned well to one side and the lids separated. The thinning and bulging of the sclerotic occurs principally at the spots which are weakened by the perforation of the vortex veins and are unsupported by the recti muscles. Such globes may become enormous, with walls as thin as paper. There is considerable danger of rupture from slight injury.

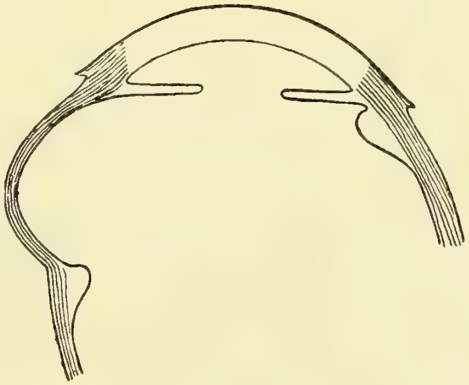


FIG. 160.—Diagram showing intercalary staphyloma.

Sooner or later the tension becomes normal or diminished in eyes with absolute glaucoma. This may be due either to stretching of the walls as already explained, or to degeneration of the ciliary body, whereby its secretory functions are diminished or abolished. Usually both factors play a part, varying according to the particular case. Such an eye may even shrink, but more commonly ulceration of the cornea occurs, owing to the defective resistance of the degenerated tissues. Hypopyon ulcer, panophthalmitis, phthisis bulbi then form the sequence of events.

Diagnosis.—Acute glaucoma is more likely to be mistaken for iritis than any other disease. The differential diagnosis has already been discussed (p. 288).

Treatment.—Acute glaucoma demands immediate energetic treatment. It is imperative that the tension shall be reduced as soon as possible. Theoretically this is best and most permanently effected by immediate iridectomy, and in most cases other measures fail. In any case they should not be dallied with too long. The moment is, however, an unfavourable one for operation. The conjunctiva is chemosed, the anterior chamber is extremely shallow, there is no time for exhaustive preparations, and a general anæsthetic will be necessary owing to the impermeability of the stretched cornea to cocain.

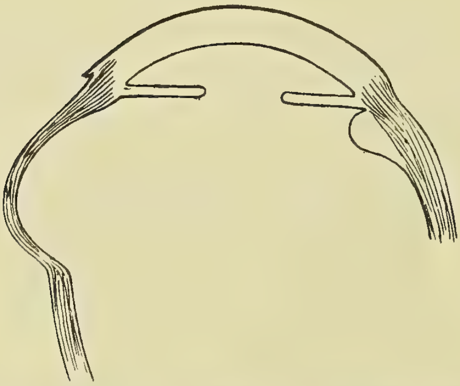


FIG. 161.—Diagram showing true ciliary staphyloma.

It is, ~~therefore~~, permissible to try other remedies for a short time first. Eserin (1 per cent.) should be instilled every five minutes for the first half hour, one drop being placed in the other eye at the commencement; the eserin drops are then continued every half hour until the tension falls or operation is decided upon. Meanwhile the eye is continually bathed with water as hot as can be borne.

[1] Owing to the constitutional disturbance & the irregular action of the heart one may [illegible] feel diffident about giving a general anaesthetic in these cases. The danger, ~~however~~, is liable to be over-estimated, & in reality, [illegible] so great as to contra-indicate operation.

~~When the effect of~~ The anterior chamber becomes deeper, thus facilitating the ~~operation~~ performance of iridectomy.

If there should be a lacrymal mucocele ~~present~~ (v.p.) present ~~the~~ both canaliculi should be ligatured, or the puncta cauterised with the actual cautery.

If both eyes are affected, both should be operated upon. In neither instance is this procedure indicated or even justified.

The prognosis of iridectomy in acute glaucoma is so good, if it be performed early, that there is no valid reason for substituting any other operation for it. Some surgeons trephine for acute, as well as for chronic glaucoma (v. p.). In my experience the technical difficulties of trephining under these circumstances are so great, & the results are less favourable than those of iridectomy.

In absolute glaucoma pain is best relieved by hot bathings & internal administration of aspirin. If possible consent should be obtained to excise the eye. It is rarely justifiable to trephine or perform any other operation merely for the relief of pain in these cases, since there is nearly always a risk that the cause of the glaucoma may be an intraocular malignant growth, usually sarcoma of the choroid.

Iridectomy was first tried for glaucoma by von Graefe (1856) on the erroneous theory that as it lowers the tension of the normal eye (which is not true) it would be beneficial in glaucoma. The ~~real~~ true explanation of the efficacy of iridectomy in glaucoma is that it reopens the angle of the anterior chamber & thus restores filtration. In acute glaucoma the iris is at first merely apposed to the corneo-sclera at the periphery. The manipulations draw it away. Part of the iris is then torn away at its ciliary attachment, & the angle of the anterior chamber is [illegible] reopened in these situations. There is some reason to think that fluid is absorbed by the cut edges of the coloboma, for wounds of the iris do not heal by cicatrisation, the lymph spaces of the stroma thereby [illegible] continuous with the anterior chamber at the cut margins.

This generally relieves some of the pain. If after an hour or two there is no sign of improvement, as indicated by distinct diminution of tension and good constriction of the pupil, iridectomy must be at once performed. Posterior sclerotomy may be employed as a temporary measure for the relief of tension whilst preparations for the iridectomy are being made (*vide* Chap. XXII.).

Even if the results are satisfactory iridectomy must be performed as soon as the eye is quiet. There is, indeed, one objection to non-operative treatment, even when successful, and to posterior sclerotomy, viz., that the patient may refuse the radical operation when the acute stage has passed off. In cases in which this is to be feared, it is advisable in the patient's interest to perform the operation at once.

Chronic Glaucoma, sometimes called simple glaucoma, is fundamentally the same disease as acute primary glaucoma; every grade of severity is met with, but the more chronic forms are so insidious that special attention must be directed towards their discovery.

The patient usually complains of transient attacks of obscuration of sight, and of gradually diminishing acuity of vision; but in some cases there may be no history of haloes and the diminution of vision is continuous and very insidious.

The eyes may appear perfectly normal at the first examination, though sometimes the anterior ciliary veins are congested, and the pupil is somewhat dilated and sluggish. An abnormally small cornea should draw attention to the possibility of glaucoma, and hypermetropia increases the probability. The tension may be quite normal, and is found to be elevated only during an attack of cloudy vision. Hence it may be necessary to examine the patient frequently and at various times in the day, especially during such attacks.

Subjective examination will often reveal no diminution of central vision. Hence it is of the utmost importance to take a careful chart of the field of vision, when some contraction of the nasal field is almost certain to be found (Fig. 162).

Ophthalmoscopic examination will often show some cupping of the disc; frequently it is far advanced, though the symptoms have been so slight as to have passed almost unnoticed. The field in these cases will be found to be much damaged.

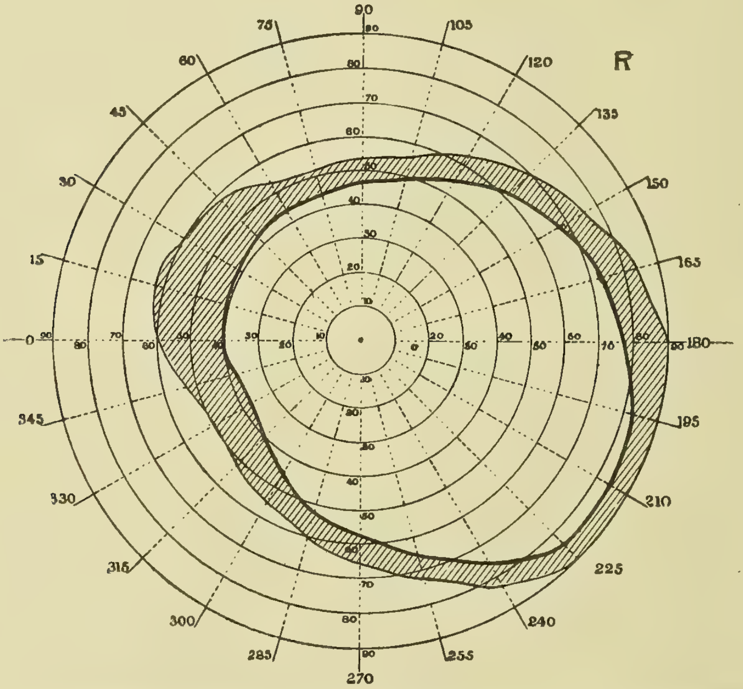


FIG. 162.—Field of vision in commencing glaucoma, showing contraction of nasal side.

Primary glaucoma invariably attacks both eyes sooner or later; usually one is considerably more advanced than the other. The chronic form sometimes occurs in young people, and seems to attack men almost as frequently as women. It also occasionally occurs in myopic eyes.

Diagnosis.—Chronic glaucoma has frequently been mistaken for cataract or optic atrophy. Cases occur in which

the gradual loss of vision is attributed to cataract, and the patient is told that nothing can be done until the cataract is ripe for operation. Vision is thus irretrievably lost. As a rule diagnosis is very easy. The haze of the pupil is bluish, diffuse and uniform, unlike the usual appearance in cataract. The pupil may be slightly dilated and generally reacts less to the stimulation of light. Examination with the ophthalmoscopic mirror in most cases renders the diagnosis certain by showing a uniform red reflex and the absence of opacities in the lens.

Doubt as to the presence of glaucoma may arise in cases with senile striæ in the lens. In patients predisposed to glaucoma the swelling of the lens which occurs in the early stages of cataract (*vide infra*) may lead to increase of the intraocular tension. The disc is not usually cupped in these cases, but there is generally more failure of vision than is accounted for by the lenticular opacity, and the field of vision may show contraction on the nasal side; the reaction of the pupil to light may be sluggish. In such cases it is advisable to do a preliminary iridectomy, which should be of the glaucoma type with a large and peripheral coloboma.

Cupping of the disc in glaucoma is accompanied by atrophy of the nerve fibres, and it may be difficult to distinguish this atrophy from optic atrophy due to other causes, especially those giving rise to what is known as "primary" optic atrophy. The latter condition shows some depression of the surface of the disc which is usually too slight to be actually measured by the ophthalmoscope, but is demonstrated by the bending of the vessels as they pass over the edge of the disc. The depression is greater in most cases of chronic glaucoma. In cases which give rise to difficulty in diagnosis little aid is afforded by the tension of the eye, which may be normal or inappreciably raised at the time of examination. Reliance must be placed upon the history of the case, the condition of the cornea and anterior chamber, and the record of the field vision. The latter shows concentric constriction in primary optic atrophy, more marked contraction of the nasal side in glaucoma. Accurate mapping out of the blind spot and the central region of the field on a large scale by placing the patient 2 metres distant from a black screen and using a small white test object (~~a disc 3 mm. in diameter~~) affords confirmatory evidence. In glaucoma there is an area of relative defect in the field which can always be traced in direct continuity with the blind spot, which is not the case in optic atrophy.

Treatment.—~~Iridectomy should be performed as soon as the condition is definitely diagnosed, the chief criterion in doubtful cases being the condition of the field of vision. If there is contraction of the nasal side iridectomy should be performed at once, even if central vision is quite normal.~~

The prognosis ~~of iridectomy in chronic glaucoma~~ is not nearly so good as in the acute form, owing to the fact that the periphery of the iris is often firmly adherent to the corneo-sclera before the condition is diagnosed. Hence special endeavour ~~must be~~ made to open up the occluded angle. ~~It is not sufficient to make the section~~ at the corneo-scleral margin, ~~since~~ when the iris is torn away it is almost certain to tear at the false angle, and little or no good results. ~~The section is made~~ as peripheral as is consistent with safety to the ciliary body, *i.e.*, 2 mm. behind the corneo-scleral margin, with the object of carrying the incision through the adherent part of the iris, ~~though~~ it must be confessed that this object ~~is probably~~ seldom if ever attained. ~~The piece of iris removed should be about one-fifth of the entire circumference.~~

~~In the more chronic~~ cases of long standing ~~this procedure~~ sometimes succeed~~s~~ in spite of impossibility of restoring the normal method of filtration. It effect~~s~~ this by establishing

~~(Bjerrum's screen)~~
~~At this distance the projection of the blind spot measures about~~
~~in diameter, or again about 2.5°~~
~~¶8~~

Until a few years ago iridectomy was the operation invariably performed for the relief of chronic glaucoma. (turn over)

If the section is made

It was customary therefore to make the section

¶ It was found, however, that this method of performing iridectomy

9d) 1 ¶ Deliberate attempts have therefore been made to establish a safe filtering scar for the relief of chronic glaucoma. Such a scar is usually formed only if there is some impediment to proper cicatrisation, as for example, when the iris is incarcerated in the wound. It is not justifiable deliberately to leave a knuckle of iris in the wound when doing an iridectomy, as has been advocated. Such a procedure involves the grave risks of [illegible] secondary infection of the eye & ~~[illegible]~~ & sympathetic ophthalmia. Even more unjustifiable is the insertion of a silk ~~[illegible]~~ thread or other drain into the wound.

¶ ~~Attempts have therefore~~ ~~[illegible]~~ ~~into either the [illegible]~~. It is not [illegible] the lips of the wound are in good apposition & sound healing rapidly takes place. This is much less likely to occur if there is a gap between the lips of the wound. Under these circumstances the gap becomes filled with loose scar tissue & a filtering cicatrix may result. Various operations have been based upon this principle. In *Lagrange's operation* an ordinary iridectomy is performed, but before closing the wound a small piece ~~of the edge~~ of the anterior lip is snipped off without wounding the conjunctival flap. In *Herbert's operation* a small rectangular trap-door is cut in the sclerotic just outside the limbus, the hinge lying towards the cornea. A circular wound in the sclerotic offers the best chance of success theoretically. This can be effected by means of a punch or a trephine. The punch has proved unsatisfactory. ~~The trephine is [illegible]~~.

Trephining ~~has~~ is the operation which is now almost invariably performed for chronic glaucoma (v. p.). By it a disc ~~[illegible]~~ 1.5 mm. in diameter, is removed from the wall of the globe just inside the limbus, so that part lies in the cornea & part in the sclerotic. The knuckle of iris which prolapses into the wound should be excised, so that a small peripheral iridectomy I is performed. If a larger disc is removed there is danger of the tension becoming permanently too low, with the risk of ~~[illegible]~~ malnutrition of the eye. The operation not infrequently fails from blockage of the wound with iris or too dense scar tissue. Other complications will be discussed later (v. p.).

I

When trephining succeeds in producing a satisfactory filtering scar it is probable that the fibres of loose connective tissue become covered with endothelium derived from that covering Descemet's membrane & the ligamentum pectinatum ~~[illegible]~~, so that permanent channels of filtration are formed. Secondary infection of the eye is liable to occur from injury of the epithelium covering the bulging conjunctiva, but it is comparatively rare & is a ~~justifiable~~ risk which may be taken justifiably in ~~an~~ treating so serious a disease as glaucoma. If trephining fails it can be repeated at some other part of the limbus, but the wound should always, if possible, be placed where it is covered & supported by the lid.

Trephining is uncertain in its results & is liable to be complicated with serious dangers, both immediate & remote, ~~[illegible]~~ yet ~~it is~~ in my opinion it affords the best means yet devised for dealing with chronic glaucoma. (to the slide) a *filtering scar*~~, i.e.,~~ O The the new scar in these cases is composed of spongy tissue, through the interstices of which the intraocular fluid is able to make its way into the subconjunctival tissue, where it is absorbed. ~~Such a scar is usually formed only if there is some impediment to proper cicatrisation, such as is caused by incarceration of the iris in the wound. The causes which lead to the formation of a filtering scar have their own dangers to the eye, and no satisfactory means of ensuring a safe scar of this nature are known. It is seldom justifiable deliberately to cause incarceration of the iris, for it does not always succeed in producing a filtering scar and is attended with serious dangers. Attempts have been made to ensure a filtering cicatrix by snipping off a small piece of the anterior lip of the wound (Lagrange's operation), making a small scleral flap (Herbert's operation), trephining, and so on. These methods are on their trial, but encouraging results have been obtained.~~

In very advanced cases the field of vision may be found reduced almost to the fixation point. Experience teaches that in these cases ~~iridectomy~~ operation may not only do no good, but may result in the sudden complete loss of all vision. After explaining this risk to the patient it is still advisable in most cases to ~~perform the operation~~ operate, because this unfortunate result is rare, and in any case the eye is likely to become painful unless the tension is relieved.

Since glaucoma always occurs in the other eye sooner or later the question of a prophylactic ~~iridectomy~~ operation in this eye arises. Since ~~the operation~~ it is attended by some danger, both immediate and remote, ~~e.g., the possibility of sympathetic ophthalmia~~, and since the advent of glaucoma may be long delayed, it is inadmissible to ~~perform iridectomy~~ operate until some slight contraction of the nasal field can be demonstrated. The greatest care must be taken to warn the patient of the danger of the disease attacking the

95 ~~[illegible]~~ A broad iridectomy performed at this early stage has a much better prognosis than one done later. [illegible] large [illegible] the [illegible] to produce [illegible] astigmatism, [illegible] trephining does not usually produce this result.

other eye, and of the earliest symptoms. He should be examined thoroughly and the field of vision taken every three months, and he should be instructed at once to consult the surgeon if any signs of the disease occur. He should also be warned against putting drops, lotions, or ointment of any kind into his eyes without the advice of an ophthalmic surgeon.

When one eye has been almost or quite lost at the time of the first visit it becomes a serious question whether the better eye should not be operated upon rather than the worse. Many such difficulties arise in the treatment of glaucoma, and can only be decided by the conditions of the individual case.

~~If iridectomy has been done in a case of chronic glaucoma and has failed, anterior sclerotomy or one of the more modern operations for the formation of a filtering scar should be performed.~~

~~It has been stated that iridectomy~~ is unconditionally indicated when chronic glaucoma is definitely diagnosed. Cases arise in which it is impossible to be certain that the disease is present, and others in which operation is refused. In such cases the pupils should be kept contracted by miotics. Eserin or pilocarpin often succeed in reducing the tension of chronic glaucoma and postponing the evil day when useful vision is lost. *They never cure chronic glaucoma.* Hence they must be adopted only as a temporary means of alleviation or as useful adjuncts. If the tension is definitely raised and operation is refused, 1 per cent. eserin should be ordered three times a day until the tension is normal. If the tension is not definitely raised the pupils should be kept moderately constricted with 0·5 per cent. or 0·25 per cent. eserin once or twice a day for a prolonged period. The stronger solutions cause considerable conjunctival and ciliary irritation if used constantly.

(9b)

h Weak pilocarpin or eserine drops may be ~~advised~~ used every other day as a prophylactic measure, & the general régime should be so ordered as to avoid cerebral congestion

Infantile Glaucoma (*Syns.—Buphthalmia, Hydrophthalmia*).—Glaucoma in rare cases attacks children, when it assumes a quite different clinical appearance. It arises from congenital blockage of the angle of the anterior chamber, due either to a congenital defect whereby the root of the iris does not become normally separated from the corneo-sclera or becomes adherent to it through intra-uterine or infantile inflammation. The fundamental condition is therefore the same as in glaucoma in adults, viz., defective filtration of lymph from the eye. The reason why it assumes so different a clinical picture is dependent entirely upon the greater plasticity and extensibility of the walls of the young eye. Instead of offering an insuperable resistance to increased internal pressure the sclerotic gives way more or less uniformly, so that the globe becomes very large.

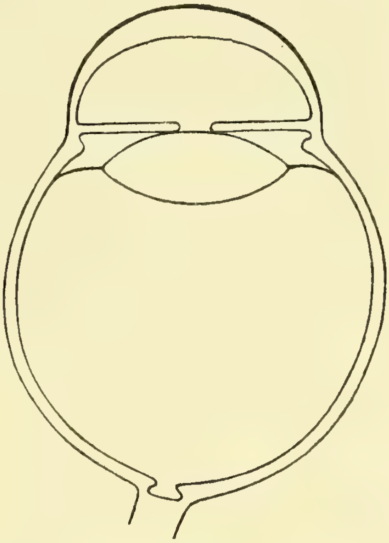


FIG. 163.—Diagram of eye with infantile glaucoma (buphthalmia). Note the stretching of the corneo-sclera at the periphery, the flattening and displacement backwards of the lens, the cupping of the disc, and the general enlargement of the globe.

The thinned sclerotic of the ciliary region is bluish in colour, owing to the uveal pigment showing through. The intercalary region, or junction of the cornea and sclerotic also gives way, so that the cornea is forced forwards and assumes a globular shape (keratoglobus). The anterior chamber is therefore extremely deep (Fig. 163). The lens does not participate in the general enlargement; owing to the expansion of the ciliary region the suspensory ligament is stretched so that the lens is flattened and displaced slightly backwards. This removes some support to the iris, which becomes tremulous (iridodonesis). The optic disc is deeply cupped if the condition has lasted long.

The intraocular tension is raised, but often scarcely appreciably as determined by clinical methods owing to the expansion of the globe. This fact for a long period prevented the true pathology of the disease from being recognised.

As a result of the expansion the eyes are usually myopic, though less than might be anticipated from their length. This is due to the flattening of the lens and its displacement backwards, as well as to some flattening of the cornea, all of which factors tend to counteract the axial myopia.

Treatment is ~~very~~ unsatisfactory. Iridectomy and sclerotomy have been employed with success, but more frequently with failure. Miotics are useless.

anterior/

The best results have been obtained from anterior sclerectomy with the trephine [illegible], & this method is also less dangerous than either iridectomy or anterior sclerotomy.

CHAPTER XV.

THE LENS.

The lens is composed entirely of epithelium, which is surrounded by a cuticular envelope or capsule. It is, therefore, subject only to degenerative changes, and is incapable of becoming inflamed. Degenerative changes in the lens invariably result in loss of transparency in the parts affected. This condition of partial or complete opacification is called *cataract.*

The degenerative changes commence by the accumulation of fluid between the lens fibres, so that spindle-shaped spaces are formed. They, in the first instance, cause opacity merely by the irregular refraction which they induce. Later, the fluid contains albuminous deposits which are actually opaque : they form globular masses, called Morgagnian globules. At a later stage the fibres break down into rounded masses which are indistinguishable from the Morgagnian globules.

Cataracts are classified according to the position and extent of the opacity or opacities in the lens, and it is found that the situation and distribution correspond with various combinations of clinical conditions—age, general disease, &c. In some cataracts the opacities spread and fuse until the whole lens becomes opaque ; such are called progressive cataracts : in others they remain stationary. Senile cataract, which is the commonest form of all, is a progressive cataract.

Senile Cataract.—This, as its name implies, rarely occurs in persons under fifty years of age.

In the *incipient* senile cataract radial spokes or sectors of opacity are seen, with clear areas between them (Figs. 164—5). They are difficult to see in daylight or by oblique illumination (*vide* p. 112), and cataract should not be diagnosed without confirmation with the ophthalmoscope. With the undilated pupil only the ends of the spokes are seen, but when the pupil is dilated with cocain or homatropin (*never* with atropin, *vide* p. 312), the linear opacities are often found to be the apices of sectors, with their bases towards the periphery. Careful examination with oblique illumination and the ophthalmoscope will show that the opacities are in the superficial parts or cortex of the lens, some in front of the nucleus, others behind. They start from the region of the equator and extend towards the axis of the eye, more and more spokes and sectors developing as time goes on. [illegible]

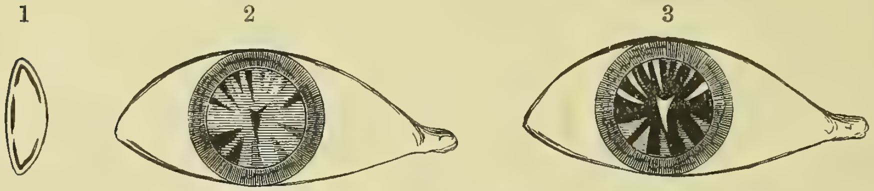


Fig. 164.—Senile cataract. 1, section, showing opacities in the cortex; 2, appearance by reflected light—dark striæ on a red background; 3, appearance by oblique illumination—grey striæ on a dark background. (Nettleship.)

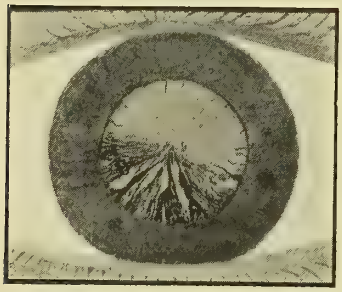


Fig. 165.—Commencing senile cataract, the striæ confined to the lower part of the lens, a very common mode of commencement.

Seen by oblique illumination the opacities are grey; seen with the ophthalmoscopic mirror at reading distance they appear black against a red background. ([illegible])

~~This~~ typical arrangement of the opacities is subject to variations. Often there are punctate opacities between the

71

(This is the typical arrangement of the opacities in senile cataract.) Two other types occur less frequently. In ~~the~~ one ~~second~~ group the opacities are supranuclear. They are more (may be distinguished as the subcapsular type) variable in appearance, [illegible] of concentric lines, radial streaks, & cloudy patches. This variety is distinguished from lamellar cataract (q.v.). In the third group the opacities are intranuclear, & which form these cases be distinguished from the congenital nuclear cataract. In this group the nucleus of the lens is diffusely cloudy, gradually clearing towards the peripheral cortex. [illegible] of the various types are not uncommon, [illegible] subcapsular [illegible] being associated with intranuclear [illegible] the latter with supranuclear opacities. Conditions [illegible] occur. [illegible] Moreover [illegible] (& lower) [illegible] pre-senile cataract, & are [illegible] form is [illegible] progressive. ~~[illegible]~~ [illegible] may appear as early as 20 to 30 years of age. [illegible] earlier (about 40) than the ordinary subcapsular.

sectors. Sometimes a diffuse opacity forms in the layers surrounding the nucleus, or they may appear simultaneously here and at the equator, or they may be scattered ~~irregularly~~ throughout ~~the cortex~~. At the very earliest stage the opacities shift with the incidence of the light, showing that they are merely differences of refractive index (*vide ~~supra~~*). p. 329).

In the progressive stage the lens contains more water than normal, and this is associated with swelling of the fibres. When the opacity has become considerable the swelling causes an appreciable *intumescence* of the whole lens, shown by the increasing shallowness of the anterior chamber. in the [illegible] type

The nucleus undergoes little change and does not become opaque, but eventually the whole of the cortex is cataractous. The cataract is then said to be ripe or *mature*. The whole of the pupillary area may appear to be opaque before the cataract is mature, since the most superficial layers of the cortex are the last to degenerate. As long as there is any clear lens substance between the pupillary margin of the iris and the opacity the iris throws a shadow upon the grey opacity when light is cast upon the eye from one side (Fig. 166, A). When the cortex is completely opaque the pupillary margin lies almost in contact with the opacity, separated only by the capsule; the iris then throws no shadow, and the cataract is known to be mature (Fig. 166 B). This is an important guide to the most favourable time for operation.

At this stage it will be found that the anterior chamber has regained its normal depth. The watery fluid has been absorbed from the lens, which has again returned to its normal volume.

If the process is allowed to go on uninterrupted the stage of *hypermaturity* sets in. The cortex is then completely disintegrated and transformed into a pultaceous mass.

Usually the loss of water continues so that the lens becomes more and more inspissated and shrunken. The lens is then flat and yellow, often with cretaceous deposits and bright specks due to crystals of cholesterin. The anterior capsule becomes thickened by proliferation of the anterior cubica cells, so that a dense white capsular cataract is formed at the anterior pole in the pupillary area. Owing to shrinkage the lens and iris become tremulous, the anterior chamber being much deepened. Degeneration of the suspensory ligament may lead to luxation of the lens.

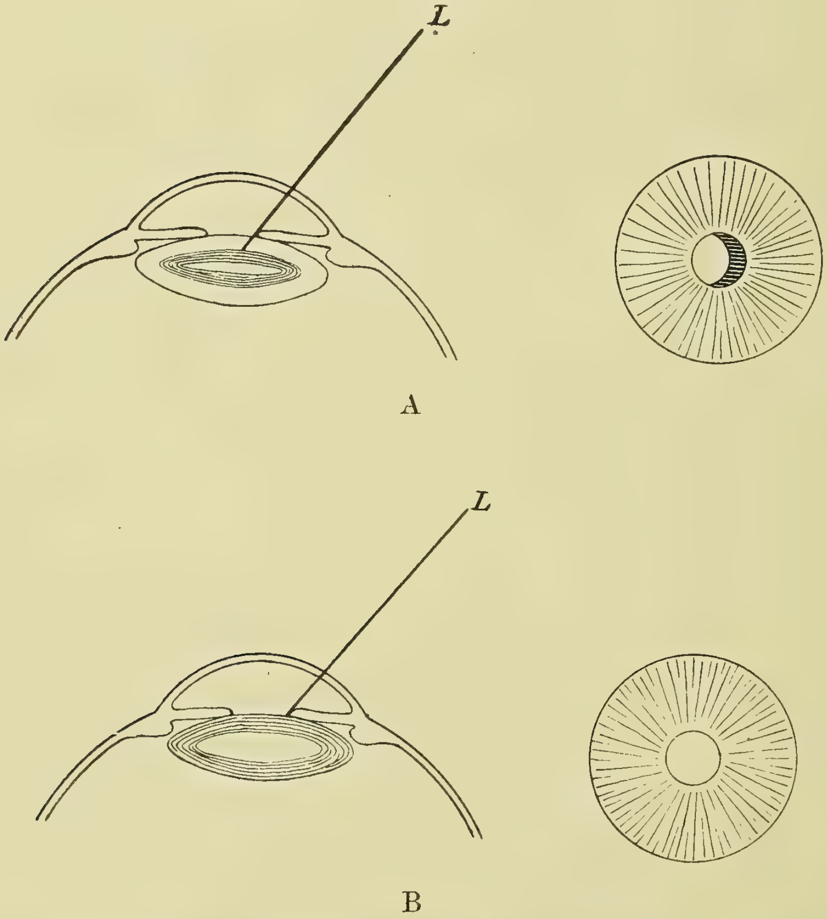


FIG. 166.—A, shadow of iris by oblique illumination in immature cataract ; B, absence of shadow in mature cataract.

Sometimes the absorption of water ceases at the stage of maturity. The cortex then becomes quite fluid, and

/ The texture contrasts the brownish appearance of the specimen by oblique illumination, gives some idea of its [illegible] and [illegible] the size of the section necessary for its removal.

the nucleus sinks to the bottom of the capsule. The liquefied cortex is milky, the nucleus appearing as a brown shading, limited above by a semicircular line. The nucleus alters its position with changes in position of the head. Such a cataract is called a *Morgagnian cataract* (Fig. 167).

In rare cases the sclerosis of the lens fibres which causes the development of the nucleus extends beyond the usual limits, so that the whole of the lens becomes converted into nucleus. Such a lens is hard, dark brown, and semi-transparent. The pupil looks black, the brownish colour being revealed only by oblique illumination. The condition is called *black cataract*, though strictly speaking it is not a true cataract.

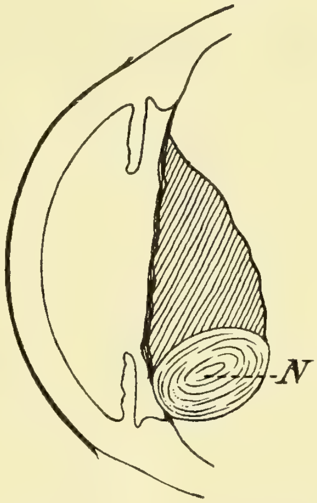


Fig. 167.—Diagram of Morgagnian cataract. N, nucleus of lens.

The mode of treatment of cataract depends largely upon the amount of central sclerosis, *i.e.*, upon the size of the nucleus. Up to about thirty years of age the nuclear fibres are still fairly soft, and capable of becoming absorbed if the aqueous gains access to them. After this age absorption is very slow and incomplete, and if cataract occurs the nucleus must be removed from the eye. The size of the nucleus then determines the size of the incision which is necessary. The cases in which the nucleus is very small are called *soft cataracts*, since they consist chiefly of soft cortical matter. In most patients over fifty the nucleus is large, and these cataracts are called *hard cataracts*, although the lens is by no means hard throughout. This only occurs in black cataract, in which the nucleus reaches its maximum size, viz., that of the whole lens. Such cataracts require a very large section for their removal.

Symptoms.—The appearance of black spots in front of the eyes is usually the first symptom complained of. They differ from the ordinary muscæ volitantes occasionally complained of in normal eyes, and much exaggerated in cyclitis, &c., in that they are stationary, retaining their relative position in the field of vision in different positions of the eye. Uniocular polyopia, another symptom, is the doubling, trebling, &c., of the objects seen with the eye. It is due to the irregular refraction of the degenerating lens, so that several images are formed of each object. It is often worst on looking at bright lights, and is therefore noticed most in the evening.

As the opacity extends and becomes denser, the acuity of central vision suffers, especially when there is much central opacity. In the latter cases vision is often better in a dull light, owing to the dilatation of the pupil. In most cases of senile cataract the pupillary region suffers latest, so that a bright light is grateful to the patient, both on account of the better illumination and also because the rays which pass through the irregularly refracting peripheral parts of the lens are cut off, but the patients seldom like to face the light.

Eventually the central area becomes affected and vision steadily diminishes until only quantitative perception of light remains. In many cases of mature senile cataract fingers can still be counted at a few feet, or at least hand movements discerned. In all cases light should be perceived readily and the direction of incidence accurately indicated. The detection of the *projection of light* is of the utmost importance, as it affords important evidence as to the probabilities of a good result from operation. It is tested as follows. The opposite eye is covered securely by the palm of the patient's hand. Light is then reflected from the ophthalmoscopic mirror into the cataractous eye from various directions, the patient looking straight forwards

He is told to point with his other hand in the direction from which the light seems to come. He ought to do this readily and accurately. If he does not, we suspect some disease of the retina, *e.g.*, patches of retino-choroidal atrophy, &c., and a less favourable prognosis is given. Relatively poor projection is not an absolute contra-indication to operation, and each case must be determined on its merits.

It will be seen that cases of advanced cataract in which the fundus cannot be satisfactorily explored by the ophthalmoscope at the first visit, and in which projection is relatively bad, offer considerable difficulties in deciding the treatment to be adopted. It is therefore of the greatest importance that every case of incipient cataract should be most carefully explored and exhaustive notes of the ophthalmoscopic condition taken, so that at a later stage, when the fundus can no longer be observed, its previous condition is already on record. Every case of incipient cataract should therefore have the pupil dilated with homatropin so that a thorough examination of the eye may be recorded. A drop of 1 per cent. eserin must invariably be instilled before the patient leaves, otherwise there is danger that an attack of glaucoma may be induced by the administration of the mydriatic. The field of vision should also be taken at this stage.

The rate of development of senile cataract varies greatly, sometimes occupying many years, or, indeed, the cataract may never reach maturity. The progress is usually more rapid in very old people. Very rapid maturation in younger patients usually indicates some complication, *e,g.*, cyclitis, diabetes, &c. The forms with fine radial lines are slower than those with cloudy opacities. It is best to examine every case at stated intervals, a careful drawing of the opacities being recorded at each visit. The length of the intervals must be determined by the individual case.

Treatment.—No treatment by drugs, &c., has any effect upon the progress of uncomplicated senile cataract.

In *incipient cataract* the condition of the patient may be much ameliorated during the tedious process of maturation. A low degree of myopia (1 D to 4 D) may develop during this stage; it is due to increase in the index of refraction of the nucleus of the lens. If found it should [illegible] be corrected. Tinted glasses may be found beneficial, the tint varying with the circumstances of the case. Amber tinted glasses are most generally useful. They cause an extraordinary increase of definition even in normal persons, a phenomenon due to psychic causes. Blue glasses, which allow the chemically active ultra-violet rays to pass, are not contraindicated in this case, since the cutting off of the more luminous rays is restful. These or smoked glasses are indicated, especially when there is a considerable degree of central opacity, since the pupils are kept slightly dilated. This effect may be obtained with greater certainty by instilling a very weak mydriatic. Atropin, $\frac{1}{16}$ to $\frac{1}{8}$ gr. to ℥ i., one drop every other day, may be ordered, if homatropin is found not to raise the tension. The slightest to ~~sign of~~ glaucoma, *e.g.*, high hypermetropia, small cornea, very shallow anterior chamber, &c., contraindicates this treatment, and it is wise to observe the tension carefully during the treatment in all cases. Sometimes weak atropin causes more blurring, in which case it must be abandoned.

There is no reason to restrict the use of the eyes in incipient uncomplicated senile cataract, but the patient may be much assisted by instructions as to the arrangement of illumination and so on. If the pupillary area is free brilliant illumination will be found best; if the opacities are largely central, a dull light beside and slightly behind the patient's head will give the best result.

In *mature cataract* the lens must be extracted. Before

2 Pathology. The cubical cells lining the anterior capsule of the lens (v. p. 12) undergo vacuolation in senile cataract. Changes in these cells can be made out ~~[illegible]~~ clinically by using a strong binocular loupe. ~~However~~ The cortical opacities are due to the formation of Morgagnian globules & the breaking up of the lens fibres (v. p. 329). Senile cataract has been attributed to changes in the cortex produced by shrinkage of the nucleus, but the evidence is unsatisfactory. Many other theories have been advanced but the most probable is that the nutrition of the lens suffers owing to metabolic changes in the general organism possibly owing to the formation or ~~[illegible]~~ failure of destruction of specific autocytotoxins.

The hydrolysis of the lens protein leads to the formation of tyrosin both in the lens & aqueous; tyrosin is not found in the normal lens (Burdon Cooper).

101 Careful search must be made for precipitates on the back of the cornea ("K.p."), for the cataract may be a ~~secondary~~ complicated cataract (v. p. 326). The urine must be tested to eliminate albuminuria & glycosuria, though these do not necessarily contraindicate operation. The state of the conjunctival sac must be ~~[illegible]~~ thoroughly examined.

102 In cases of doubt the eye may be tied up with a pad & bandage for one night. The pad is examined on the following morning. If there is any discharge together with conjunctival secretion, or if the lids are gummed together, repeated bacteriological examinations and further treatment ~~under~~ are indicated. It is ~~[illegible]~~ inadvisable to bathe the eye in the night previous to operation, for it is found that this ~~then~~ favours the growth of bacteria in the conjunctival sac.

[illegible]

deciding to operate, attention must be paid to details other than those connected with vision, previously described. ~~Most important amongst these is the state of the conjunctival sac.~~ If there is the slightest conjunctivitis, and above all, if there is dacryocystitis, a course of preliminary treatment is necessary. Old people frequently suffer from chronic conjunctivitis induced by senile ectropion, &c. It is best treated by relieving the cause as far as possible, and the use of astringent lotions. An occasional painting with silver nitrate is the most potent means which we possess of removing infective organisms from the conjunctival sac in these cases, since they are carried away mechanically with the desquamated epithelium, &c. Often the process is long and tedious, and doubt as to the safety of operating still persists. In such cases a bacteriological examination should be made, and if pathogenic organisms are found, especially virulent pneumococci, operation must still be postponed.

The presence of a mucocele is an absolute contraindication to operation. It must be cured (Chap. XXX.), or the lacrymal sac must be excised, or the canaliculi must be temporarily obliterated. The latter may be effected by tying a ligature round each canaliculus or by cauterising each punctum with the actual cautery. The best treatment is usually excision of the sac.

In every case the eye to be operated upon should be tied up with a pad and bandage the night before operation. The surgeon must examine the pad himself, and if there is any discharge upon it, or if the lids are gummed together with inspissated secretion, the operation must be postponed.

The treatment of *unilateral* and of *immature cataract* offers some difficulty. When the cataract is mature in one eye whilst the other retains good vision little advantage is gained by operating upon the cataract. The difference in refraction between the two eyes after operation will be so great that it will be impossible for the patient to see well if the refraction is corrected, and if uncorrected the large blurred images formed by the eye may be a positive disadvantage. The sole advantage which is gained is an increase of the field of vision on the affected side. This may be a matter of great importance, as in people who work amidst machinery or have to go about where there is much traffic ; in these exceptional cases extraction is indicated. There is also the slight advantage that the eye is prepared for the time when vision fails in the less affected eye, but this may be long delayed. These slight advantages do not as a rule justify operation, which, it must be remembered, is attended with some, if usually trivial, danger, not only to the eye operated upon, but also to the other eye (*vide* p. 456). On the other hand, the cataract must not be allowed to progress to too advanced a condition of hypermaturity. Operation is then more difficult and more dangerous. The case should be watched, and if signs of thickening of the capsule, calcareous deposits, &c., appear, extraction should be performed even though the vision in the other eye is still good.

Cases of immature cataract with loss of useful vision require even more skill in the determination of the best time for operation. The difficulties and dangers of extraction are undoubtedly increased by operating whilst there is still a large amount of clear soft cortex. It is difficult to remove from the eye, tends to the production of iritis and other complications, and leads to the formation of dense secondary cataract (*vide* p. 345). Immaturity, however, is not an absolute bar to operation ; extraction under these circumstances may be followed by perfect results. It must be remembered that the patients are old, and, if not operated upon, are doomed to practical blindness, which in the lower classes entails the loss of

[The [illegible] of the [illegible] should not be performed until
all [illegible] after the preliminary, in [illegible]]

all wage-earning capacity. Operation will probably be attended by at least the recovery of useful vision, whereby the conditions of existence are much ameliorated. It is not necessary, therefore, to wait indefinitely for complete maturity if useful vision has already been lost.

Some surgeons temporise in these cases, performing a preliminary iridectomy, on the grounds that the operation accelerates the ripening of the cataract. It certainly occurs in rare cases, but is by no means constant. Preliminary iridectomy has the advantage of facilitating the subsequent extraction, but has the considerable disadvantage of subjecting the patient to the discomforts and dangers of two operations instead of one. It may be employed in complicated cases in which it is desired to test the reaction of the eye to operative interference, for it is a less severe operation than extraction, and will afford indications as to the advisability of further procedures. It is also to be advocated in cases with much diffuse opacity, often more concentrated in the central part of the posterior cortex, for in them the diminution in visual acuity is very marked, maturation is indefinitely delayed, and the complications produced by a large amount of sticky cortex are much to be feared.

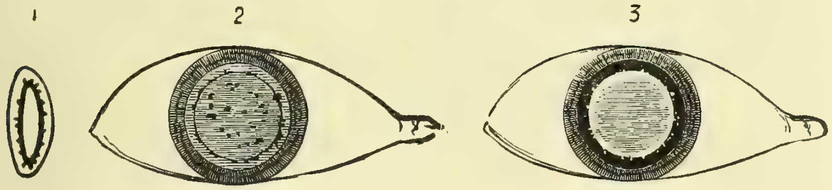


FIG. 168.—Lamellar cataract. 1, 2, 3, as in Fig. 164. (Nettleship.)

Cataracts of Congenital or Infantile Origin.—These are almost always partial and stationary. The commonest forms are lamellar and anterior capsular ; less common are the various forms of congenital cataract, mostly of lamellar type, sometimes central or total.

Lamellar Cataract (*Syns. — Zonular, Perinuclear Cataract*).—This usually occurs so early in infancy that it is doubtful if it is not congenital. Although there is no true nucleus at this early age the central parts of the lens are conveniently termed the nucleus. The opacity in lamellar cataract is situated in the layers surrounding this central core, which itself usually contains punctate opacities; the superficial cortex is quite clear (Figs. 168—170). When the pupil is dilated a grey discoid opacity is seen, surrounded by a perfectly transparent marginal area. The diameter of the disc varies, that of the clear peripheral area varying inversely. With the mirror the disc appears black and sharply defined at the outer edge, diminishing in density towards the centre; the peripheral area shows a normal red reflex. Along the outer edge spokes of opacity, resembling the handles of a steering wheel, often extend slightly into the clear area (Fig. 169). They are called riders, and are due to spindle-shaped opacities between the lens fibres in layers a short distance outside the main opacity. Occasionally two concentric rings of opacity are seen. The cataract is usually stationary, but cases occur in which total opacity gradually develops. Both

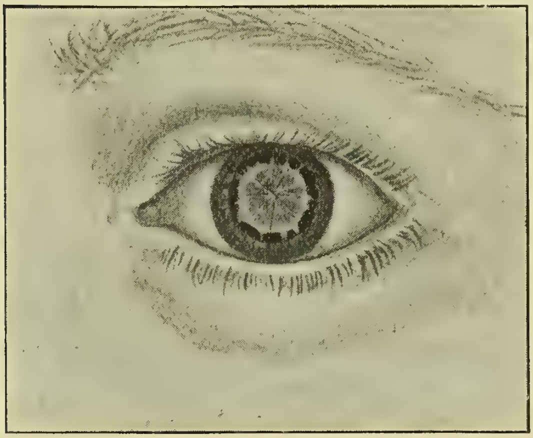


FIG. 169.—Lamellar cataract

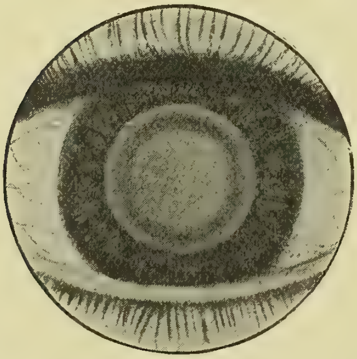


FIG. 170.—Lamellar cataract with very slight opacity. V = $\frac{6}{12}$.

(The time at which the pathological process took place is indicated by the size, the diameter of the opacity [illegible] teeth affected with hypoplasia. Only those teeth are affected whose enamel germs are being formed at the time. As regards the lens the youngest fibres are the most superficial (p. 15), so that the diameter of the opacity indicates the size of the lens at the time. Concentric rings of opacity are accounted for by successive periods of malnutrition.)

in a myopic
(~~Symptoms~~. The patient is brought on account of defective vision; he is thought to be "short sighted" - he usually holds objects very close to the eyes [illegible] but the approximation [illegible] is indeed not uncommon in these cases, but the approximation of object is usually for the purpose of obtaining larger retinal images (p.)

eyes are almost always affected, though not always to the same degree.

The opacity is always sufficiently large to fill the area of the undilated pupil. The diminution of vision is therefore entirely dependent upon the density. ~~The patients are usually said to be "near-sighted," because they hold objects close to the eyes in order to obtain larger retinal images.~~

There is no doubt that lamellar cataract is due to a period of malnutrition at some stage of late intra-uterine or early infantile life. This is shown especially by the almost invariable accompaniment of defective enamel in certain of the permanent teeth. The hypoplasia differs essentially from the condition of the teeth in congenital syphilis. The teeth have an eroded appearance, with transverse lines across them, the incisors and canines being most affected (Fig. 171).

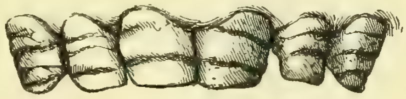


FIG. 171.—Hypoplasia of teeth.

The cause of the malnutrition is probably to be found in errors of feeding and possibly exanthemata. There is some reason to think that rickets is a cause, and congenital syphilis has been indicted, but on insufficient grounds. A history of convulsions is ~~extremely~~ common. very

Treatment depends upon the density and the diameter of the opacity. In cases with dense opacity and very poor vision with undilated pupils the treatment depends upon the diameter of the opacity. If it is small with a wide area of clear cortex, and if distant vision is much improved when the pupil is dilated and the refraction corrected so far as possible, an optical iridectomy ~~should~~ be performed. These must cases are, unfortunately, quite uncommon. Usually the opacity is large, and it is then necessary to remove the lens, which has the grave disadvantage that it abolishes accommodation. Since the patients are almost always seen when quite young, the central core of the lens does not yet form a hard nucleus. Non-sclerosed lens fibres become absorbed if the aqueous gains access to them. Hence lamellar cataract can be treated by discission or needling, whereby an aperture is made in the anterior capsule through which the aqueous enters. This is the ordinary treatment of lamellar cataract, but it should not be employed unless the vision is seriously impaired or the other methods of treatment are impossible. As all varieties of density are met with the advisability of needling in cases with fair vision has to be considered. The decision of this question depends upon whether vision with corrected refraction and retained accommodation is to be preferred to probably improved vision after operation without accommodation. I am of the opinion that vision of 6/12, or even 6/18, with retained accommodation, is more valuable than a problematic 6/9, or even 6/6 without accommodation, but with the necessity of wearing constantly very strong convex glasses. I do not therefore operate in such cases.

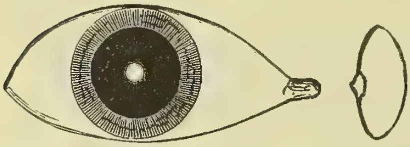


FIG. 172.—Anterior capsular cataract. (Nettleship.)

Anterior Capsular Cataract (*Syn.—Anterior Polar Cataract*).—This form of cataract is commonly known as anterior polar. It is best to reserve this term for any cataract at or near the anterior pole of the lens, since there are two forms of anterior polar cataract, viz., anterior capsular and anterior cortical. Similarly the term posterior polar should be used in the same manner, though there is more ambiguity here. There are two forms of opacity which are known as posterior polar cataract. The posterior cortical cataract is the commonest form of complicated cataract (*vide* p. 347) (Fig. 176). The other posterior polar "cataract" is not a cataract at all, since it

[strictly ~~speaking~~

p, though there is always some opacity of the adjacent lens fibres (v. p. 355).

| especially one due to epithelial proliferation,|

p, or [illegible] formation of the [illegible] chambers |

is due to persistence of part of the posterior vascular sheath of the lens, and is therefore situated upon the posterior surface of the lens, *i.e.*, it is not a true lenticular opacity (Fig. 178).

Anterior capsular cataract is due to proliferation of the cubical cells which line the anterior capsule (Fig. 173), and is usually limited in uncomplicated cases to a small area in the centre of the pupil (Fig. 172). The stimulus to proliferation is caused by contact with the normal or inflamed cornea. Contact of the lens with the normal cornea only causes opacity in the lens if it occurs at an early age. This is indeed fortunate, for if it were not so most intraocular operations, *e.g.*, iridectomy, would be impossible. In very young children it is probable that a very short time of contact is all that is necessary. The older the patient the longer is the time required. Contact with an inflamed cornea is more liable to produce an anterior capsular cataract than with the normal cornea. In most cases it is due to perforation of a corneal ulcer, more rarely to a perforating wound.

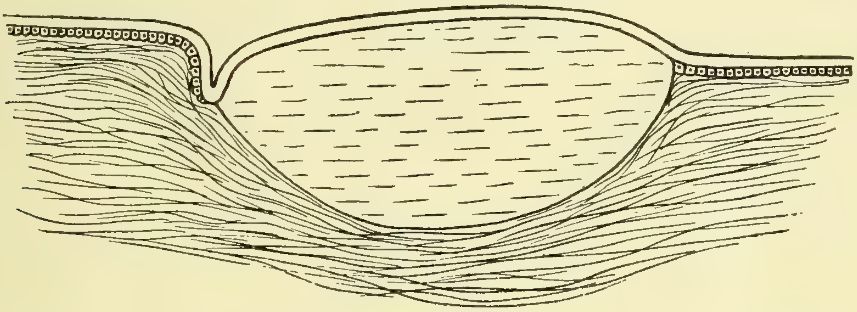


FIG. 173.—Diagram of section of anterior capsular cataract.

Anterior capsular cataract is sometimes congenital, when it is also probably due to contact with the cornea, possibly without actual perforation. In these cases it is almost always bilateral, whereas the acquired form is generally unilateral.

When an ulcer perforates the aqueous escapes and the lens and iris are driven forwards into contact with the back of the cornea. If the perforation becomes blocked with iris the anterior chamber re-forms, the length of time of contact between the lens and cornea varying in different cases. If it is short, no harm may be done to the lens, unless the patient is very young. If it is more prolonged an anterior capsular cataract is formed and the lens adheres more or less to the wound. When the anterior chamber re-forms the lens usually separates completely from the cornea : less frequently the adhesion stretches out into a fine filament, which may persist or break. Occasionally the adhesion is so firm that the lens is permanently anchored to the cornea ; the eye is usually lost by panophthalmitis or secondary glaucoma in these cases.

The dragging upon the adhesion when the anterior chamber is re-formed may cause a conical protrusion of the cataract—*pyramidal cataract* (Figs. 111, 172).

The deleterious effects of contact may affect the underlying cortical fibres, so that an anterior cortical cataract may occur with a capsular one. In the absence of cortical degeneration the opacity is so small and sharply defined that vision is little impaired, and no treatment is required.

Congenital Cataract manifests itself in a variety of different forms. As already stated, anterior capsular and typical lamellar cataracts may be congenital. Many other forms are nearly allied to the lamellar type. To this category belong the following :—

Central or nuclear cataract, a small spherical opacity in the centre of the lens, surrounded by clear cortex.

Fusiform cataract, also called spindle-shaped, axial, or coralliform, an antero-posterior spindle-shaped opacity, sometimes with offshoots giving an appearance much resembling coral : this form shows a great tendency to occur in families.

In other congenital cataracts minute points of opacity h, those occurring early in intrauterine life being small in brain (K. & Z. p. 341)

In such cases the cubical cells which line the anterior capsule also persist : they continue to fulfil their function of forming new lens fibres, though those formed under the abnormal conditions are abortive and opaque (Fig. 174). If these remnants lie in the pupillary area a dense membrane is formed through which the rays of light penetrate with difficulty, so that vision is very imperfect. If the previous operation has been followed by iritis, exudates also adhere to the lens remnants and organise, thus contributing a fibrous membrane in addition.

Secondary cataract is demonstrated either by oblique illumination or by the ophthalmoscope. If fine, it may be difficult to see, forming a grey film by the former method, a cobweb-like haze by the latter. The denser membranes are easily recognised. They vary in density, showing coarse opaque bands separated by more transparent areas.

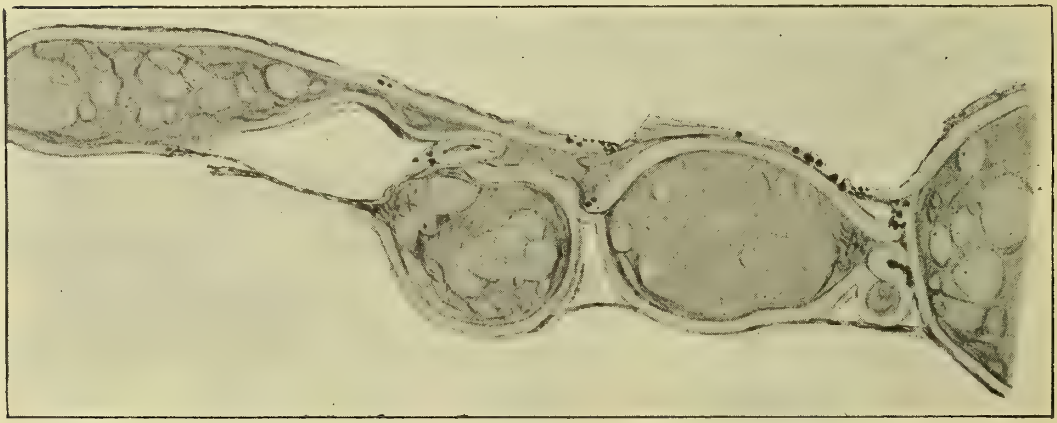


FIG. 174.—Secondary cataract from a section by Treacher Collins.

Treatment.—Secondary cataract requires needling (*vide* p. 472).

Complicated Cataracts (*Syn.—Secondary cataracts*) are those forms which result from malnutrition of the lens, due to disease of other parts of the eye or of the general system. The lens is nourished by lymph which is supplied by the ciliary body. If, owing to disease of the ciliary

body or to lymph secreted from abnormal blood, the nutrition of the lens suffers, opacities are formed. They usually commence in the centre of the posterior part of the cortex, and are therefore at first *posterior cortical cataracts* (often called posterior polar) (*vide* p. 342) (Figs. 175—6). The opacity seldom remains confined to this situation: it progresses, affecting first the periphery of the anterior cortex close to the nucleus, finally involving the whole cortex. In many cases the opacities are fine and dust-like, and are scattered throughout the cortex from the commencement, increasing in number and density as time goes on.

The total cataract formed in this manner is usually soft and uniform in appearance. In still later stages the watery constituents become absorbed, the capsule becomes thickened, the whole lens shrinks, giving rise to tremulousness of the iris, and other degenerative changes—calcification, &c.—ensue.

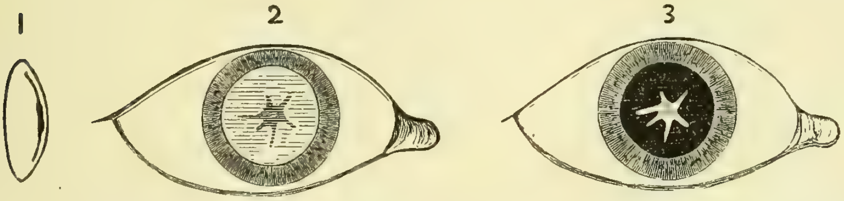


FIG. 175.—Posterior cortical cataract. 1, 2, 3, as in Fig. 164. (Nettleship.)

Complicated cataracts occur in advanced cases of cyclitis, in absolute glaucoma, in choroido-retinitis—disseminated choroiditis, "retinitis" pigmentosa, &c.—in high myopia, in detachment of the retina, &c.; they also occur in suppurative inflammation of the cornea, especially that produced by ulcus serpens. The opacity in the posterior cortex, which is generally stellate in shape, is seen in its most characteristic form in "retinitis" pigmentosa, in which disease also its slow progress can be easily watched. The vision is already much diminished before complicated cataract makes its appearance. This fact is of the utmost importance from the prognostic point of view, since, even if the cataract is successfully removed, the progressive diminution in vision due to changes in the fundus is not thereby influenced. In every doubtful case not only must the central and peripheral vision be carefully investigated, but an exhaustive search must be made for precipitates upon the back of the cornea.

Treatment must be directed in the first case to the cause of the complication. This is often tedious and unsatisfactory, but must be persevered in as long as useful vision persists. If then the perception and projection of light appear to be fairly good, and the cataract is of a nature suitable for operation, it should be removed by discission or extraction, according to the age of the patient. Many cases are not suitable for operation, mostly on account of the very defective vision and projection of light. Even in these if there is a possibility of success, operation may be undertaken after warning the patient of the doubtful issue, for the loss of such an eye weighs little against a possibility of improved vision. It is wise in these cases to do a preliminary iridectomy (*vide* p. 339).

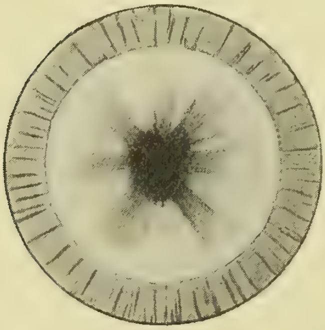


FIG. 176.—Posterior cortical cataract (posterior polar cataract), seen by reflected light.

Diabetic Cataract should be regarded as a form of complicated cataract. Cataract in diabetic persons is by no means always diabetic in the proper sense of the term. Senile cataract of the usual type, following the usual course, often occurs, and should be treated in the ordinary manner, though in the early stages the general disease must invariably receive every attention, both in the matter of diet and drugs. True diabetic cataract is comparatively rare. It is always bilateral. Dusty opacities appear throughout the

cortex and rapidly increase until total cataract supervenes. A uniform milky opacity of rapid onset should always suggest the possibility of diabetes, though of course the urine should be tested as a matter of routine in all cases of cataract.

Diabetic cataract, though usually occurring in patients with a large percentage of sugar in the urine, is not due to the mere presence of sugar in the aqueous, for it is never sufficiently concentrated to cause cataract *per se.* The cause is unknown, but is probably some deleterious agent in the lymph secreted by the ciliary body.

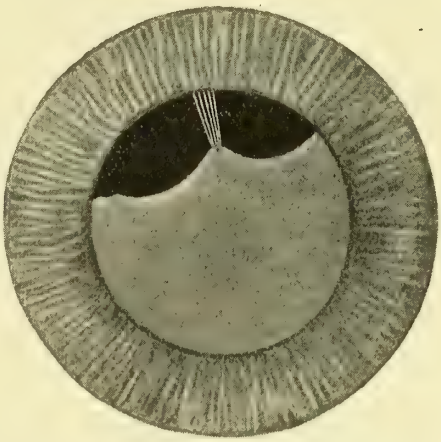


FIG. 177.—Coloboma of the lens (Marcus Gunn). The direction of the coloboma, upwards, is somewhat unusual. Note the defective development of the suspensory ligament of the lens.

Treatment.—It is imperative in all cases of true diabetic cataract to treat the general condition before adopting operative measures. It is rare for the opacity to clear up under such treatment; but since cases do occur, and since operations upon the eyes of diabetic patients have special dangers of their own, this chance should always be afforded.

If general treatment is unsuccessful the cataract must be extracted. In spite of the special difficulties attending the operation the results are often quite satisfactory, though a guarded prognosis should be given. Contrary to what might be anticipated, the wound usually heals well. The special dangers are local and general. Of the former, the tendency to severe iritis and to hæmorrhage are the most important. The necessary manipulation of the iris is likely to set up traumatic iritis of a peculiarly violent type.

Iridectomy in the course of the operation may be attended with much hæmorrhage, which not only obscures the view of the field of operation, but may endanger the eye : violent intra-vitreous or subchoroidal hæmorrhage may destroy the eye at the time of operation. ~~Diabetic cataract is the one form of cataract in which~~ simple extraction, *i.e.*, extraction without iridectomy, ~~is definitely indicated~~. The chief danger affecting the general system in these cases is the risk of the sudden onset of diabetic coma. It is comparatively slight, and must be guarded against as far as possible by a suitable course of anti-diabetic treatment before operating.

Traumatic Cataract.—See p. 447.

Persistence of the Posterior Vascular Sheath (*Syn.—Posterior Polar Cataract*).—See p. 355.

Congenital Abnormalities of the Lens.

Besides the various forms of *congenital cataract* (*vide* p. 344), abnormalities in the shape and position of the lens occur.

Coloboma of the lens is the condition in which there is a defect in the inferior margin, usually notch-shaped ; less frequently it occurs in some other part of the margin (Fig. 177).

Ectopia lentis or congenital dislocation is a subluxation of the lens, usually upwards or up and in, and bilateral. The condition is often hereditary. The lens is small, but the edge is generally invisible until the pupil is dilated. The usual signs of subluxation (*vide* p. 439) are then seen.

Rarer forms of cataract. – Bottle-maker cataract

Hence it is desirable to remove a diabetic cataract by/

or, at any rate, without a peripheral button-hole iridectomy (v. p.). Another
grave danger is that of septic infection. If it occurs panophthalmitis rapidly
supervenes, owing to the very defective resistance of the tissues.

It, often associated with other malformations of the eye.

It is due to defective development of part of the suspensory ligament.

Preliminary Investigation of the Patient.

The student is recommended to study each patient according to the following scheme:

(1) **General condition of the patient.**

(2) **Position of the head.**—Characteristic in paralyses of extra-ocular muscles.

(3) **Face.**—Note asymmetry, facial paralysis, affections of the skin, *e.g.* herpes ophthalmicus, etc.

(4) **Position of the eyebrows.**—Vicarious action of the frontalis in ptosis, etc.

(5) **Orbits.**—Exophthalmos, enophthalmos, etc.

(6) **Eyeballs.**—(*a*) Position and direction—strabismus.
(*b*) Movements.
(*c*) Size and shape—microphthalmia, glaucoma, myopia, buphthalmia, staphyloma, etc.

(7) **Lids.**—(*a*) Position—ptosis, ectropion, entropion, etc.
(*b*) Palpebral aperture—ptosis, exophthalmos, etc.
(*c*) Movements—ptosis, exophthalmic goitre, etc.
(*d*) Margins—blepharitis, tumours, etc.
(*e*) Lashes—trichiasis, distichiasis, etc.
(*f*) Glands—hordeolum, chalazion, etc.
(*g*) Puncta lacrymalia—eversion, occlusion, etc.
(*h*) Lacrymal sac—swelling, regurgitation, etc.

(8) **Conjunctiva.**—(*a*) Palpebral—congestion, granulations, scars, concretions, ulcers, etc.
(*b*) Ocular—congestion (conjunctival and ciliary), secretion, phlyctenules, growths, wounds, etc.
(*c*) Plica semilunaris—displacement in pterygium, growths, etc.
(*d*) Caruncle—inflammation, granulations, growths, etc.

(9) **Cornea.**—(*a*) Surface—corneal reflex, abrasions, ulcers, foreign bodies, etc.
(*b*) Transparency—ulcers, nebulæ, keratitis (superficial and deep vascularisation), "k. p.," striate opacity, etc.
(*c*) Size—glaucoma, buphthalmia, etc.
(*d*) Curvature—conical, buphthalmia, anterior staphyloma, abrasions, etc.

(10) **Sclerotic.**—(*a*) Curvature and colour—myopia, staphyloma, episcleritis, etc.
(*b*) Vessels—ciliary injection, episcleritis, scleritis, etc.

(11) **Anterior Chamber.**—(*a*) Depth—(*α*) shallow—perforating wound, glaucoma, dislocation of lens, etc.; (*β*) deep—buphthalmia, irido-cyclitis, dislocation of lens, etc.; (*γ*) irregular—iris bombé, dislocation of lens, etc.
(*b*) Contents—cloudy aqueous, hypopyon, hyphæma, foreign bodies, dislocated lens, etc.

(12) **Iris.**—(*a*) Colour—muddy in iritis, heterochromia (congenital and in irido-cyclitis), atrophy, ectropion of uvea, melanomata, etc.
(*b*) Position, especially plane of surface—iris bombé, retraction in irido-cyclitis, pseudoglioma, etc.

(13) **Pupils.**—(*a*) Relative size.
(*b*) Reaction to light—direct, consensual, maintenance of constriction.
(*c*) Reaction on convergence.
(*d*) Synechiæ—anterior and posterior.

(14) **Intraocular tension.**—Increased in glaucoma, irido-cyclitis; diminished in irido-cyclitis, perforation or rupture of the globe, etc.

(15) **Central vision.**

(16) **Lens.**—By oblique illumination and the ophthalmoscope.

(17) **Vitreous.**—Opacities, fluidity, foreign bodies, hæmorrhage, "retinitis proliferans," persistent hyaloid artery, etc.

(18) **Fundus.**—(*a*) Optic disc—blurring of the edges, swelling, cupping, colour, crescents, etc.
(*b*) Retinal vessels—size, contour, tortuosity, etc.
(*c*) General view—retinitis, choroiditis, etc.
(*d*) Periphery.
(*e*) Macula.

The Correction of Errors of Refraction.

If the patient is less than 15 years of age:

(1) Test the distant and near vision if the child knows his letters;

(2) Test the pupil reactions;

(3) Test the muscular balance by the screen test.

Then order ung. atropini, 1 per cent., to be inserted with a glass rod, three times a day for at least three days. At the next visit:

(1) Determine the error of refraction by retinoscopy;

(2) Thoroughly examine the fundus with the ophthalmoscope;

(3) Confirm the retinoscopy by subjective tests if the child knows his letters;

(4) Order the correction according to the principles enunciated in the textbook.

If the patient is between 15 and 25 years of age the same procedure should be adopted, but in many cases the prolonged action of atropin so seriously interferes with the patient's employment that it must be replaced by homatropin.

If the patient is between 25 and 40 years of age:

(1) Test the distant vision, the manifest hypermetropia, and the near vision;

(2) Test the pupil reactions and the range of accommodation;

(3) Thoroughly examine the eyes with oblique illumination and by the ophthalmoscope.

If it is concluded that the defect is simply due to error of refraction the further procedure depends upon the results of the subjective testing:

(1) If the vision is $\frac{6}{6}$ and J. 1, with a low degree of manifest hypermetropia and few asthenopic symptoms, glasses may be ordered according to the amount of manifest hypermetropia;

(2) If the vision is less than $\frac{6}{6}$, no Hm., but J. 1 is read fluently when the type is held closer to the eyes than normal, the patient has probably simple myopia. In general homatropin should be instilled, and the glasses ordered according to the retinoscopy and subjective tests under the mydriatic. The expert may feel justified in ordering glasses without using a mydriatic, judging by the subjective tests and his ophthalmoscopic examination, confirmed by retinoscopy without a mydriatic;

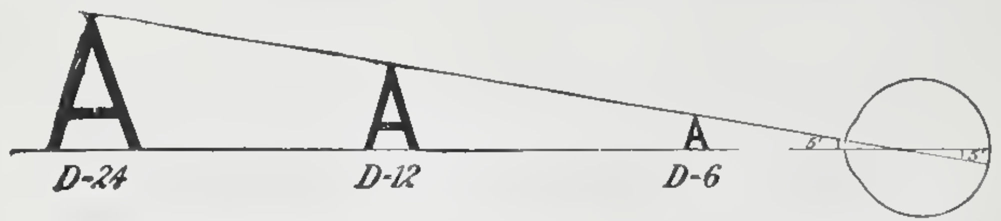
(3) If the vision is less than $\frac{6}{6}$ and $\frac{6}{6}$ cannot be read with any spherical glass, or if some letters only of $\frac{6}{6}$ can be read—letters with oblique lines, *e.g.* Z, being missed in that and even in the other lines—the patient is probably astigmatic. Homatropin must be instilled, and the refraction corrected by retinoscopy.

If the patient is over 40 years of age the examination will be exactly as for one between 25 and 40, except that presbyopia must be taken into account, and greater care must be exercised in instilling a mydriatic. Presbyopia affects the distant vision in hypermetropes in such a manner that, although $\frac{6}{6}$ may not be read with the unaided eye, it may be possible with a convex lens. If the vision cannot be improved up to $\frac{6}{6}$ with a spherical lens the patient is probably astigmatic or has some disease of the eye, *e.g.* incipient cataract. If ophthalmoscopic examination indicates merely the presence of astigmatism homatropin should be instilled, but **in every case in which this is done one drop of eserin, 0·5 per cent., is instilled into the eye before the patient leaves.**

It is advisable to see the patient again after the effects of homatropin have passed off before ordering glasses for near vision. The ordinary rule for presbyopic loss of accommodation, viz. 1 D for each five years after 40 up to 60, is a rather liberal allowance. **In no case should more than this amount plus the amount of hypermetropia be ordered,** and patients are often more comfortable with slightly less.

Snellen's Test-Types for Distant Vision.

These are constructed on the principle of an average minimum visual angle of 1′. Each letter subtends an angle of 5′ at the nodal point of the eye when placed at the given distance from the eye, the breadth of each constituent line of the letter subtending an angle of 1′.



The top line fulfils these conditions when placed **60** metres from the eye, the second at **36** m., the third at **24** m., the fourth at **18** m., the fifth at **12** m., the sixth at **9** m., the seventh at **6** m.

Distant vision is recorded thus:

$$V. = \frac{\text{distance of patient from the test types.}}{\text{distance at which the last line read ought to be read with average normal vision.}}$$

e.g. V. $= \frac{6}{36}, \frac{6}{12}, \frac{6}{6}, \frac{3}{60}$, etc.

If the 60 m. line cannot be read when the patient is close to the types the distance at which fingers can be counted is recorded. If fingers cannot be counted the hand is moved between the patient's eye and a source of light (V. = hand movements). If hand movements cannot be appreciated perception of light is tested (V. = p.l., or V. = no p.l.).

Adlard & Son, Impr.,
London and Dorking.

The Lancet Sept. 14 - 07

Reviews and Notices of Books.

Diseases of the Eye: A Manual for Students and Practitioners. By J. HERBERT PARSONS, D.Sc., M.B., B.S. Lond., F.R.C.S. Eng., Assistant Ophthalmic Surgeon, University College Hospital; Assistant Surgeon, Royal London (Moorfields) Ophthalmic Hospital. With 15 coloured plates and 308 woodcuts. London: J. and A. Churchill. 1907. Pp. 664. Price 10*s.* 6*d.* net.

IT is difficult for the most original of authors to present to his readers any great novelty in the mode of discussing the subjects that must be dealt with in a manual of ophthalmology intended for the use of the large classes of senior students and of junior practitioners; for it is only the student in the last year or two of his attendance in the wards of a hospital or the young practitioner in the first year or two of his professional work who has the time or the inclination to master the details of so large and important a subject as the diseases of the eye. Yet there are few departments of medicine the study of which is more interesting, owing to its numerous relations with other branches of science, or which, when successfully pursued and applied, is more useful to man. The author of this work has excellent qualifications for the office of a teacher. He is connected with a special hospital presenting the most extensive field of observation of diseases of the eye in England. As curator of the museum at Moorfields he has large opportunity of examining the exceptional as well as the more common diseases of the eye. And the works which he has already published on the pathology and on the physiology of that organ show that he has not neglected opportunities which have now enabled him to produce one of the most useful manuals to be found in any language.

In recommending the volume to the junior members of the profession we may remark generally that it is of handy size, clear print, and that it possesses excellent illustrations, those in particular showing the macroscopic changes in the iris and retina, many of which are coloured, being exceptionally instructive. Finally the space accorded to each division of ophthalmology is fairly in accordance with its importance to the learner. In the plan of the work the arrangement in chapters or divisions is—anatomy and physiology, examination of the eye, the diseases in topographical order, errors of refraction, disorders of motility of the eye, diseases of the adnexa of the eye, and some appendices specifying the requirements of the public services.

As might be expected from Mr. Parsons's familiarity with pathological researches, this aspect of the diseases of the eye is brought into prominence to the great advantage of the student, since much of our knowledge of the intimate changes taking place in inflammation of opaque tissues is derived from the investigation of the processes occurring in the transparent tissue of the cornea. We are tempted to transcribe the account, or rather a part of the account, of the process of ulceration in the cornea to show the mode in which accurate pathological knowledge is brought to bear by Mr. Parsons not only on the limited area of the cornea but upon inflammatory affections generally. After describing the usual form of an ulcer in the progressive stage as saucer-shaped with walls thickened from imbibition of fluid and the presence of numerous leucocytes, he points out that a line of demarcation is formed as in necrosis elsewhere. The toxins are most concentrated near the centre where the organisms are most numerous but dead owing to their virulence. Then, as Leber showed, a ring or wall of leucocytes containing many nuclei forms a second line of defence. Here the leucocytes are neither paralysed nor killed by toxins but are able to exert their digestive functions, removing by dissolving or digesting the necrotic tissues. The process of reparation is then described and with vascularisation the regressive stage is reached, the stages of which are given. But in certain circumstances some of the toxins elaborated by the bacteria diffuse through the cornea into the anterior chamber, where they exert an irritative effect upon the vessels of the iris and ciliary body, causing hyperæmia of the iris, and in severe cases the formation and discharge into the aqueous from the vessels of numerous leucocytes which gravitate to the bottom of the anterior chamber where they form an hypopyon. "There are several important facts about hypopyon," Mr. Parsons continues, "which must be borne in mind. The pus cells do not come from the cornea as was once thought. This is proved by the following facts: 1. Descemet's membrane is impermeable to leucocytes though fluids pass readily through it. 2. The cells sometimes contain pigment granules obviously derived from the uveal tract. 3. If the ulcer have not perforated the hypopyon is sterile. The last fact is of the very greatest importance both theoretically and practically. It shows that the leucocytosis is due to toxins, not to actual invasion of bacteria which indeed are as incapable of passing through the intact Descemet's membrane as are leucocytes. It accounts for the ease and rapidity with which hypopyon is often absorbed; it may develop in an hour or two, rapidly disappear, and as readily reappear. Such hypopyons are very fluid, always moving to the lowest part of the anterior chamber if the position of the patient's head be changed. The fact that the hypopyon is sterile has great practical importance—it is unnecessary to remove the pus as is the rule in all other parts of the body; if the ulcerative process can be stopped the hypopyon will be absorbed." Of course in exceptional cases its removal becomes necessary.

Cataract and the operations for its removal are described succinctly but in quite sufficient detail for the junior practitioner. As a matter of fact, the cases requiring extraction of the lens do not in general fall to his lot. To be successful the diagnosis must be satisfactorily made and the surgeon must know the steps of the operation and must not only have the appropriate instruments but they must be in perfect order, a blunt point to the Graefe's knife often leading to undue pressure upon the globe and loss of vitreous. Mr. Parsons confines himself in the diagnosis of errors of refraction to the employment of the shadow test, yet the application of this test can hardly be learnt from books except in the dark room of a hospital with an expert at hand to explain the difficulties which so often arise and which often prove puzzling even to him. We have seen several cases excellently determined by the late Mr. Hulke by the "slit" test alone and this method might have been given as an alternative and certainly much easier method than skiascopy.

The chapter on Sympathetic Ophthalmia is written in accordance with the lights of the present day, but supplies sufficient evidence that this is still a dark corner of ophthalmology and affords little help to the general practitioner who is suddenly confronted with a wound in the globe and has to determine whether he should attempt to apply the ordinary rules of surgery or at once proceed to its removal. The fact is, that we require many more clinical histories of carefully observed cases, supported by such pathological details as Mr. Parsons, Mr. E. Treacher Collins, and other expert microscopists can supply. We want to know why a prick with the point of a pin is followed in one case by no more than a trifling local inflammation and in another apparently exactly similar by the most disastrous results, not only to the injured eye alone but to the opposite one. We want to know better than we do at present the means or channels by which the evil influence is conveyed from the excitor to the sympathising eye, and, above all, we want to know the treatment that should be adopted at the early and at the later stages of the affection, the grounds inducing us to preserve the injured eye in one instance and to extirpate it in others, and when it is proper to deal with the sympathising or uninjured one. We notice that little is here said of any distinction between sympathetic irritation and sympathetic inflammation, yet antiseptics and rest in a darkened chamber with some general treatment will sometimes altogether remove the one and have little or no beneficial influence on the other. The treatment proposed for penetrating wounds in the ciliary region (p. 437) though correct for an expert with all appliances at hand seems too difficult for the junior practitioner. It would not be advisable, we think, for an unpractised hand in a case of a cut with a penknife, a very common form of injury, to insert fine silk sutures into the sclerotic but which are not to be tied, "great care being exercised not to press unduly on the eye. The prolapsed iris and ciliary body are then excised as in the operation for simple prolapsed iris. The scleral sutures are then tied. Finally the conjunctiva is sutured over the wound." The student or general practitioner would, we think, be better advised to send such cases to some large centre where the operation could be undertaken by one who is familiar with the operative surgery of the eye, or, failing this, to wait a week or two, and if the appearances were threatening and no improvement took place to remove the eye; as a rule, a delay of a fortnight does no harm.

We have left ourselves no space to comment upon the sections devoted to the neurology of vision and upon the disorders of the motility of the eye. These, no less than the others, are thoroughly worked up to date, and the book as a whole may be regarded as a very sure guide to the student and as representing the practice of one of the best schools of ophthalmology in Europe.

Le Sol et l'Eau. (*Soil and Water.*) Par L. DE LAUNAY, Professeur à l'École des Mines; E. A. MARTEL, Auditeur au Comité Consultatif d'Hygiène; ED. BONJEAN, Chef du Laboratoire du Comité Consultatif d'Hygiène de France; et J. OGIER, Chef du Laboratoire de Toxicologie de la Faculté de Médecine de Paris. With two coloured plates and 80 figures in the text. Paris: J. B. Baillière et Fils. 1906. Pp. 460. Price Fr.10.

THIS book, which constitutes the second fasciculus of a treatise on hygiene published under the editorship of Professor P. Brouardel and M. E. Mosny, deals in a most exhaustive and interesting manner with the examination of the characters of the soil in regard to the problems of human habitation and with the general properties of water from a hygienic point of view. It commences with a geological study of the soil by M. L. de Launay in which the general characters of soil and sub-soil are described. Geological maps and sections are illustrated and their uses indicated. The constitution of the soil and the penetration of water through it are described.

M. Bonjean contributes a chemical and bacteriological study of the soil and discusses the rôle of the soil in regard to human habitation. He gives in detail the chemical composition of the different varieties of earth, and describes their physical properties. The relations of bacteria to the soil are given in detail, the problem of nitrification is discussed and the general distribution of pathogenic and other organisms, with their vitality in the soil, are described. The mortality rates of dwellers upon different kinds of soil and the nature of the so-called telluric affections concludes this section.

The geological relations of water are contributed by M. E. A. Martel. In this section the origin and nature of subterranean waters are described in detail and these waters are classified. The essential characters of potable waters are laid down and the various sources of pollution are considered, with the means to be adopted for counteracting them. The various possible sources of water—viz., rain, small springs, wells, rivers, lakes, and the sea are each separately dealt with, and the legal procedures necessary for the effective control of the supply of drinking water are summarised.

The remaining section of the book is contributed by M. Ogier and M. Bonjean and deals with the examination of water from the microbiological and chemical points of view. It occupies more than half the total pages of the book and is one of the most thorough and complete studies of the subject with which we are acquainted. The various characters of potable waters are given very carefully and the methods of water examination are described in detail, with especial descriptions of the methods used in the laboratory of the French Committee of Hygiene. The various bacteria found in water are separately considered and their morphological and cultural characters presented very clearly. The ordinary intestinal parasites and their ova and other small animal organisms sometimes found in water are described and figured. The various methods for the chemical analysis of water are next given and the significance and value of the results obtained are discussed. A very considerable amount of attention is given to the methods of purifying and improving the water-supply, and in this connexion the methods for filtration on a large scale are referred to and discussed, the special forms of filter like the Pasteur-Chamberland and the Berkefeld are figured and the methods of purification by chemical processes are also dealt with. An interesting account is given of certain methods for the sterilisation of water by means of ozone generated by electrical apparatus.

The book as a whole is a very valuable contribution to the works of reference on the subject of hygiene and is worthy of the reputation of the editors.

Hay Fever, Hay Asthma: Its Causes, Diagnosis, and Treatment. By WILLIAM LLOYD, F.R.C.S. Edin., Surgeon-in-Charge of the Nose, Ear, and Throat Department, Queen' Jubilee Hospital; Surgeon to the Nose and Throat Department, St. Pancras and Northern Dispensary. London Henry J. Glaisher. 1907. Pp. 95. Price 3*s.* 6*d.*

THE author explains in his preface that his chief reason fo writing this book was to record certain opinions which h holds upon the causes and effective treatment of hay fever He admits that these opinions are not exactly in accordanc with those generally current in this country but is convinced he says, from a considerable experience that they are sub stantially correct. He divides cases of hay fever int two distinct clinical types, dependent upon the predisposin pathological cause. In the first type, on examination of th nose no structural abnormality is discovered, but certai areas of the mucous membrane are hypersensitive. In th second, some pathological condition or abnormality present, together with hypersensitive areas. Amongst th intranasal diseases present he mentions simple chron catarrhal or hypertrophic rhinitis, polypi, sinus disease ethmoiditis, adenoids, deflected septum, spines and crest and foreign bodies, or rhinoliths. Mr. Lloyd considers tha his first group forms the true type of hay fever, and th symptoms are only produced by the action of pollen; th second group, he suggests, should be termed pseudo ha fever; the symptoms are much the same, but may come during any period of the year. We think, however, that it not desirable to include the second group under the headi of hay fever but to designate them according to the morb condition which exists. The main etiological factor is qui different, in the one the pollen is the prime cause of t disease, whilst in the other the pollen is of only seconda importance.

In regard to treatment Mr. Lloyd lays great stress on t importance of cauterising the hyperæsthetic areas. Obvi abnormalities such as adenoids and polypi must, of cour be removed, but this procedure, he says, will not always gi the expected relief, and the electric cautery must then applied to the areas just named. This method of treatm

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Elementary Ophthalmic Optics, including Ophthalmoscopy and Retinoscopy. By J. HERBERT PARSONS, B.S., B.Sc. Lond., F.R.C.S. Eng., Curator of the Royal London Ophthalmic Hospital. London: J. & A. Churchill. 8vo, pp. 162. 1902.

THE object of this well-written work is to enable the student to comprehend the principles which guide him in the diagnosis of errors of refraction, in the application of the ophthalmoscope, and in the employment of that mode of determining the refraction of the eye termed "retinoscopy." It is divided into 11 chapters which are successively devoted to the consideration of Light, Reflection, Refraction, Lenses, the Homocentric System, the Dioptric System of the Eye, Ametropia, the Ophthalmometer, the Ophthalmoscope (which occupies two chapters), and Retinoscopy. To read this book with advantage it is necessary that the student should possess some knowledge of trigonometry and algebra in order that he may follow the author's demonstrations, but scarcely more is demanded than a lad from the upper forms of a public school has acquired. Several igures are introduced into the text and these figures the reader should construct for himself. Many questions involving a knowledge of the laws of optics for their solution present themselves in the selection of glasses in ametropia, in the determination of the position of foreign bodies in the ransparent media, and in the explanation of the phenomena observed in retinoscopy, and it would be well if all who ntend to practise ophthalmic medicine and surgery were to make themselves familiar with the fundamental principles of optics. The importance of this knowledge has been clearly ecognised by the opticians, and it is only necessary to point out that such knowledge forms part of their examinations and that instructive and sometimes very able articles, essays, and answers to inquiries are given weekly in the well-conducted but thoroughly business journal the *Optician*—answers that, we venture to say, could be given by but few f those students who leave our ophthalmic wards.

of Darwin taken by the late Mrs. Cameron.[2] Its price, half-a-crown, puts it within the reach of everyone, and it is a book worth keeping.

La Santé de l'Ecolier. By Dr. C. DELVAILLE and Dr. A. BREUCQ. Paris: Fernand Nathan. Third edition. 1902. Pp. 281.

THE need in France for a work on school hygiene, such as that before us, is probably more urgent than in this country, for to a large extent the natural instinct for physical recreation which is so characteristic of English school-boys and in a lesser degree of English school-girls also, constitutes an effective prophylaxis against the evils which inevitably occur from the close segregation of a large number of children in class-rooms. In France hygienic methods have not heretofore received the attention which they have in this country, and with a declining population and a low birth-rate it is a matter of national importance to protect in every possible way the health of the rising generation. The fact that French children take little delight in organised games renders the task of maintaining discipline during school hours a doubly difficult one and at the same time makes it all the more necessary to press into the service of State pedagogy every device of practical hygiene which can better the conditions of school life. This little treatise has been mainly written for the use of teachers in Government schools or for those who are concerned with disciplinary management. It contains chapters on a variety of questions affecting the personal hygiene of the student, the care and examination of the organs of special sense, and the structure of school buildings and of class-rooms, their lighting, decoration, and

Folia Therapeutica October 1907

DISEASES OF THE EYE. By J. Herbert Parsons, D.Sc., M.B., B.S., F.R.C.S., Assistant Ophthalmic Surgeon, University College Hospital, etc. (Published by J. and A. Churchill, 1907. pp. 664. Price 10/6 net.)

The study of ophthalmology must be based on a substantial groundwork of the special anatomy and physiology of the eye, together with an accurate appreciation of the principles of optics. The author of this new manual recognises this demand, and devotes some 90 pp. to the normal functions of the eye before dealing with clinical considerations. In the treatment of ophthalmic diseases, only the well-established methods are mentioned, all matter of doubtful value or historical interest being omitted. An appendix on therapeutic notes is added. It contains a fair summary of the use of Dionin, but the mention made of the organic preparations of silver is not so favourable. A special feature to be noted in this book is that errors of refraction are very fully treated of in the early part of the volume, before the use of the ophthalmoscope is considered. This is obviously the only logical procedure, because the use of this instrument is so often vitiated by the presence of errors of refraction, which are not duly appreciated. On the other hand, the correction of errors of refraction is deferred to a late section of the book.

the United States or the British Pharmacopœias, so that those interested in these preparations will find herein a veritable mine of information, otherwise difficult of access. The whole work is a great monument of the industry and erudition of the editorial staff.

SURGICAL EMERGENCIES. By Percy Sargent, F.R.C.S., Surgeon to Out-patients at St. Thomas' Hospital, etc., etc. (Published by Henry Frowde and Hodder & Stoughton, London. Oxford Medical Publications. pp. 256. Price 5/- net.)

We have here a rapid review of surgical accidents and diseases, with definite directions for treatment. A very extensive subject is therefore treated in a very brief compass. This necessarily introduces inevitable limitations. Most of the procedures described deal with operative details; the directions are certainly explicit, but hardly ample enough to teach any but experienced surgeons how to grapple successfully with surgical emergencies. The book would have fulfilled its purpose better if attention had been confined to those conditions wherein skilled and timely aid is demanded, and can be rendered by a practitioner who is not prepared to undertake serious surgical operations. As it is, practically the whole field of operative surgery is traversed by the author, and the result, though accurate, concise and authoritative, is much too wide for the

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Diseases of the Eye,* by Mr. J. HERBERT PARSONS, is a new book intended for students. It is arranged carefully, so as to lead the beginner from the anatomy and physiology of the eye to the more important diseases to which it is subject. It contains 654 pages, and is illustrated by upwards of 300 cuts and plates, those showing some of the more important ophthalmic conditions being coloured. The discussion of elementary optics and physiological optics is more elaborate than usual in such a textbook, but the author is convinced that the true appreciation of these things "is the only sure basis of correct diagnosis and successful treatment." The numerous diagrams and the clear way in which the text is written make these chapters more attractive than is often the case. A very short chapter is then given to the neurology of vision. The second section consists of 80 pages, and is devoted to a description of the examination of the eye. The third section, which comprises the greater part of the book, discusses the diseases of the eye, commencing with the conjunctiva, taking each structure of the eye in succession. It must suffice to say that the descriptions are lucid and to the point, while the illustrations, both the black-and-white and the coloured, are excellent.

There is a somewhat inadequate paragraph on colour blindness; but possibly the author thinks that the examination and detection of this condition is too technical to be considered fully in a book of this sort. The fourth section deals with errors of refraction, and the principles of retinoscopy are fully explained. In the fifth section disorders of motility are considered, while the sixth section describes the diseases of the lids, lacrymal apparatus, and orbit. There are three appendices; the first describes the preliminary investigation of the patient, and notes in a systematic manner the points to be observed when examining the eye. The second consists of therapeutic notes, and gives formulae for various applications and their uses. The third gives the requirements as regards vision for the admission of candidates to the public services. The book is well got up, and will take its place among the best textbooks for students.

opular Guide to the Income Tax

aining a good deal of simple information on the subject of ncome tax returns, appeals, and repayments. He explains ow incomes are classified for tax purposes and offers a umber of hints as to the making of returns and the anner in which overcharges can be avoided. Like many ther "popular guides," however, the book is by no means ree from inaccuracies. One of these is a statement, thrice epeated, that a partner claiming exemption or abatement ay be separately assessed. This is an error which appears o have arisen from an imperfect understanding of the provisions of the Finance Act, 1907. Again, in an appendix of orms of account prepared by the author for the use of taxayers, there is included an account for professional men hich contains a serious blunder. On one side of the ccount "Cash Receipts" are to be entered, yet among the eductions to be shown on the opposite side are "Bad and oubtful Debts." It is obvious to every one having an lementary knowledge of book-keeping that the effect of rediting in the account cash receipts and not gross bookgs is automatically to provide for bad debts, as sums not aid are never brought in as a receipt at all.

nevitable platitudes in this part. The bulk of the book s, of course, taken up by the consideration of the nurse's

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[14] *Pharmacopoeia of the University College Hospital, 1907.* Edited by eginald R. Bennett, A.I.C., Pharmacist to the Hospital. London: ruscott and Son, Ltd. (Pp. 92. 2s. 6d.)

[15] *First Aid to the Injured.* Six Ambulance Lectures by Dr. Friedrich smarch, Professor of Surgery at the University of Kiel. Translated y H.R.H. Princess Christian. Seventh edition. (Smith, Elder, and o., London. 1907. Pp. 138; 46 illustrations.)

[16] *Introduction à la Psychiatrie Clinique.* Par le Professeur Emil raepelin. Traduit sur la seconde édition allemande par M. Albert Devaux et Prosper Merklen. Préface de M. le Dr. upré. Paris: Vigot Frères. 1907. (Roy. 8vo, pp. 453. Fr. 12.)

[17] *Mathison's Popular Guide to the Income Tax Schedules, with Specimen orms and Full Instructions.* The Agency for the Recovery of Income ax, Brighton. (Paper cover; pp. 23. 6d.)

considerably increase the value of the work.

The Practitioner March 1908

Diseases of the Eye. By J. Herbert Parsons, D.Sc., M.B., B.S., F.R.C.S., Assistant Ophthalmic Surgeon, University College Hospital; Assistant Surgeon, Royal London Ophthalmic Hospital; Ophthalmic Surgeon, Hospital for Sick Children, Great Ormond Street, etc. Pp. 664. London: J. & A. Churchill. 10s. 6d. net.

Mr. J. Herbert Parsons is to be congratulated upon the excellence of this manual, which he has written for students and practitioners. The work deals in a very practical manner with the commoner diseases of the eye; those with which the practitioner is most likely to meet. The portion which refers to treatment is excellent, for only the well-established methods are discussed and described, while those of questionable value have been wisely omitted. For senior medical students and general practitioners we consider the book to be an ideal one.

Reviews of Books.

Cancer of the Womb; Its Symptoms, Diagnosis, Prognosis, and Treatment. By F. J. McCann, M.D., F.R.C.S., Physician to the Samaritan Hospital, London. London: Oxford University Press. 20s. net.

For many years, the author has been collecting the material to enable him to write a book on cancer of the womb, and this material he has used to excellent advantage, as shown in the work before us. He uses the word cancer in a comprehensive sense, so as to include carcinoma, sarcoma, and deciduoma malignum, so that we have a complete treatise on malignant

Edin. Med. Journal October 1907

Diseases of the Eye: A Manual for Students and Practitioners. By J. Herbert Parsons, F.R.C.S. London: J. & A. Churchill.

In view of the many excellent Manuals of Diseases of the Eye available for the use of students and practitioners, we see no reason for adding to the number. Consequently a new manual is expected to justify its appearance. This the author has attempted to do mainly by facilitating the student's progress from his knowledge of the normal anatomy and physiology of the parts concerned to the consideration of their morbid anatomy and pathology. Throughout the work the anatomy and physiology of the various structures dealt with are at the outset very carefully considered, so that physiology and pathology are linked together in a manner which gives the book a standing all its own. Then the description of the fundamental and optical principles are carefully elaborated, the true appreciation of which being the only sure basis of correct diagnosis and successful treatment. In other respects the arrangement of the book is practically the same as that adopted in other similar manuals, except that retinoscopy and the correction of errors of refraction by spectacles have been deferred to near the end of the volume, as the author considers that this is the proper place for seriously attacking the diagnosis and correction of refractive and accommodative anomalies. With this contention we do not agree, for, in our opinion, refraction, which is the keynote to many ophthalmic affections, should be studied at an early stage in a course of ophthalmology, otherwise the causation of many diseases is unintelligible.

If this new volume is to outrival its predecessors, it will be because of the excellent way in which anatomical and physiological conditions are described, and of the soundness and freshness of its pathological teaching. The book is worthy of the author—one of the foremost ophthalmic physiologists and pathologists of the present day. We have thoroughly enjoyed its perusal, and have the greatest pleasure in recommending it.

recent research in clinical pathology has influenced our conception of cardiac disease, and its elucidation ante-mortem, but the author tells us very little about some of the most interesting physiological problems that may be met with in such cases. No direct reference is made to the effect of vagus stimulation upon the heart, to the extra-systole, nor to disturbance of excitability either of the auriculo-ventricular bundle or of the auricular and ventricular musculature; the description of the jugular pulse is too fragmentary to be of material assistance to the reader, and no adequate explanation is advanced for the peculiar distribution of pain in angina pectoris.

Diseases of Women. By G. Ernest Herman. Third Edition.
London: Cassell & Co.

Dr. Herman's "Diseases of Women" is one of the clearest and most practical books on the subject extant. There has recently been published a third edition, which has been revised throughout, and in parts added to and improved. Two of the opening chapters are devoted to neurasthenia and hysteria respectively, and in them the author gives a concise account of these conditions, and expresses his views on the relationship between them and disorders of the female sexual organs with a lucidity and moderation that carry conviction. Of the newer matter, the section on chorion-epithelioma is still rather short, especially from the clinical standpoint; but it is excellently illustrated histologically by three fine micro-photographs of Dr. Teacher's. New and good illustrations have also been added to the chapter on malignant disease of the uterus. This subject is discussed in some detail, and the section on the diagnosis of cervical cancer is specially to be commended. Here, as throughout the volume, the author's vast clinical experience has enabled him to place the subject before the reader in the most practical light.

In all its sections the book is quite up to date, and the more recent work has been criticised and sifted in a masterly way, with the result that all irrelevant and controversial matter has been excluded, to the advantage of the reader, be he student or practitioner. The arrangement